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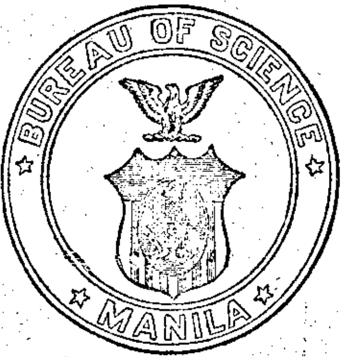

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NOTES ON PHILIPPINE EUPHORBIACEAE, III

By ELMER D. MERRILL
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In this series,[1] including the present paper, about one hundred previously undescribed species of Euphorbiaceae have been characterized, while a number of others have been considered either because of their being new to the Philippine flora or because of questions of nomenclature involved. The present paper contains the descriptions of thirty-eight presumably new species and the records of several others not previously recorded from the Philippines. The genera *Wetria*, *Megistostigma*, and *Plukenetia* are new to the Archipelago, *Megistostigma* being of special interest, the genus having been previously a monotypic one known only from the Malay Archipelago. It is of considerable interest to note the continued increase in the number of Philippine species in the small or comparatively small genera *Blumeodendron*, *Trigonostemon*, *Excoecaria*, *Omphalea*, and *Codiaeum*.

PHYLLANTHUS Linnaeus

PHYLLANTHUS PANAYENSIS sp. nov.

Frutex dioicus, ramulis exceptis glaber; foliis numerosis, plerumque lanceolatis, chartaceis, 1.2 ad 3 cm longis, nitidis, basi leviter inaequilateralibus, late rotundatis et plus minusve cordatis, sursum angustatis, acutis vel acuminatis, nervis utrinque circiter 10, tenuibus; floribus circiter 2.8 mm diametro, perianthii segmentis 6, ellipticis ad oblongo-ellipticis, 1.2 mm longis, obtusis; filamentis 3, liberis, antheris verticaliter dehiscentibus, floribus ♀ plerumque solitariis, pedicillatis, pedicello usque ad 12 mm longo.

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[1] Notes on Philippine Euphorbiaceae, Philip. Journn. Sci. 7 (1912) Bot. 379–410; 9 (1914) Bot. 461–493.

A dioecious shrub, glabrous except the branchlets, the branches slender, terete, grayish-brown. Leaves very numerous, mostly lanceolate, chartaceous, 1.2 to 3 cm long, 4 to 10 mm wide, somewhat olivaceous, shining, the base usually more or less inequilateral, broadly rounded and often slightly cordate, narrowed upward to the acute or somewhat acuminate apex; lateral nerves slender, about 10 on each side of the midrib, spreading, not prominent, anastomosing; petioles 1 mm long or less; stipules slenderly acuminate, from a broadened base, about 2 mm long. Staminate flowers fascicled, axillary, but one or few flowers appearing at the same time, each fascicle with numerous, crowded, small bracteoles, the pedicels slender, 6 to 8 mm long, the perianth 2.8 mm in diameter, the segments 6, equal, elliptic to oblong-elliptic, obtuse, 1.2 mm long. Disk glands 6, prominent. Filaments 3, about 1 mm long, free, the anthers dehiscing vertically, 0.2 mm long. Pistillate flowers axillary, mostly solitary, their pedicels in fruit up to 12 mm long, the perianth similar to that of the staminate flowers. Styles 6, free, 1 mm long. Fruit globose, about 4 mm in diameter, composed of three dehiscent cocci.

PANAY, Capiz Province, Mount Bulilao, *Bur. Sci. 35655, 35679 Martelino & Edaño,* June 20, 1919, in forests near the summit, altitude about 650 meters.

The alliance of this species is manifestly with *Phyllanthus lancifolius,* Merr., from which it is especially distinguished by its smaller leaves, its pubescent branchlets, and much shorter pedicels of the pistillate flowers.

PHYLLANTHUS APICULATUS sp. nov.

Frutex glaber, ramis ultimis circiter 7 mm diametro, cicatricibus magnis instructis, ramulis confertis, tenuibus, usque ad 40 cm longis; foliis numerosis, chartaceis, nitidis, oblongo-ellipticis, 3 ad 4.5 cm longis, basi acutis, apice acuminatis et plerumque apiculatis; floribus fasciculatis, breviter pedicellatis, circiter 4 mm diametro, segmentis 6, elliptico-oblongis, 1.8 ad 2 mm longis, staminibus 3, filamentis liberis, antheris verticaliter dehiscentibus.

A glabrous shrub, the ultimate branches terete, about 7 mm in diameter, marked with large scars, these subtended by several small, broadly ovate, stipule-like bracts, the tip and uppermost axils supplied with small, dense rosettes of oblong-lanceolate, acuminate scales; branchlets crowded toward the tips of primary ones, slender, up to 40 cm in length, somewhat simulating pinnate leaves, 2 mm in diameter or less, terete or somewhat angular near the nodes, the apical portion distinctly angular. Leaves numerous, chartaceous, the upper surface dark brown and shining when dry, the lower paler, oblong-elliptic, 3 to 4.5 cm long, 1.3 to 2 cm wide, subequilateral, narrowed to the acute base and to the distinctly acuminate and often apiculate apex; lateral nerves slender, about 9 on each side of the midrib, anastomosing, the reticulations rather close, distinct; petioles 2 mm long or less; stipules lanceolate to ovate-lanceolate, acuminate, about 3 mm long. Staminate flowers axillary, fascicled, their pedicels about 5 mm long, the perianth about 4 mm in diameter, the lobes 6, equal, elliptic-oblong, rounded or obtuse, 1.8 to 2 mm long. Disk glands 6, globose, conspicuous. Stamens 3, their filaments erect, free, 1.5 mm long, the anthers longitudinally dehiscing, 0.5 mm long.

LUZON, Camarines Province, Paracale, *Bur. Sci. 33813 Ramos & Edaño,* November 29, 1919, in damp forests at low altitudes, indicated by the collectors as 2 meters high.

This species may be as closely allied to *Phyllanthus securinegoides* Merr. as to any other species, although it is radically different from the latter in its somewhat thickened ultimate branches bearing the elongated, slender branchlets more or less crowded at the apices.

PHYLLANTHUS INDICUS (Dalz.) Muell.-Arg. in Linnaea 32 (1863) 52, DC. Prodr. 16² (1866) 417.

Prosorus indicus Dalz. in Hook. Kew Journ. Bot. 4 (1852) 346.

LUZON, Camarines Province, Mapid, *For. Bur. 22655 Alvarez,* November, 1911. PALAWAN, Aborlan, *Bur. Sci. 15589 Fénix,* July, 1912. MINDANAO, Agusan Province, Tipgon River, *Weber 1195,* July, 1911, with the Visayan name *bungas.* In forests and thickets at low altitudes.

The numbers cited are all in fruit, but they agree perfectly with a full series of Javan specimens representing this species. It has not previously been reported from the Philippines. India and Ceylon to Java.

GLOCHIDION Forster

GLOCHIDION PHYLLANTHOIDES sp. nov. § *Hemiglochidion.*

Arbor parva, glabra, vel partibus junioribus leviter pubescens; foliis oblongo-ellipticis, chartaceis, 2 ad 3 cm longis, apice rotundatis, basi acutis vel leviter rotundatis, nervis utrinque circiter

5, tenuibus; floribus ♂ perianthii segmentis oblongo-ellipticis, obtusis, usque ad 3 mm longis, antheris 3; floribus ♀ breviter pedicellatis, ♂ simillimis, ovario glabro, stylis continuis, cylindraceis, haud constrictis.

A small glabrous tree or the younger parts very slightly pubescent, the branches dark-colored when dry, lenticellate, the branchlets slender, reddish-brown. Leaves oblong-elliptic, chartaceous, 2 to 3 cm long, 1 to 1.5 cm wide, the apex rounded, base broadly acute or somewhat rounded, nearly equilateral; lateral nerves about 5 on each side of the midrib, slender, the reticulations indistinct; petioles 2 to 3 mm long; stipules lanceolate, acuminate, 1.5 to 2 mm long. Flowers axillary, fascicled, the staminate ones with pedicels up to 9 mm in length, the perianth segments oblong-elliptic, obtuse, up to 3 mm long, anthers 3, about 1 mm long, united. Pistillate flowers with pedicels about 2 mm long, the perianth segments similar to those of the staminate flowers. Ovary and style about 2 mm long, cylindric, glabrous, the latter about as thick as the ovary and not at all constricted.

LUZON, Batangas Province, Mount Batulao, *Bur. Sci. 22358 Ramos*, July 30, 1914, on dry slopes, altitude about 190 meters.

This species is apparently most closely allied to *Glochidion breynioides* C. B. Rob., from which it is easily distinguishable by its rounded or obtuse leaves.

GLOCHIDION FALCATILIMBUM sp. nov. § *Hemiglochidion.*

Frutex glaber, circiter 2 m altus; foliis subcoriaceis, falcatis, valde inaequilateralibus, oblongis, usque ad 5 cm longis, apice obtusis vel rotundatis, basi acutis vel acuminatis, nervis utrinque circiter 8, tenuibus; floribus ♀, segmentis 6, oblongo-obovatis ad oblongo-spatulatis, 2 ad 2.5 mm longis; ovario glabro, columno stylari quam ovario duplo longioribus, continuo; staminibus, 3.

A glabrous shrub about 2 m high, the branches brownish, the branchlets slender, reddish-brown. Leaves subcoriaceous, oblong, conspicuously falcate and very inequilateral, 4 to 5 cm long, 1 to 2 cm wide, rather pale and slightly shining when dry, the lower surface often slightly glaucous, the apex obtuse to rounded, the base acute to acuminate, one side very much narrower than the other; primary lateral nerves about 8 on each side of the midrib, slender, not prominent; petioles about 3 mm long; stipules lanceolate to ovate-lanceolate, acuminate, falcate, 2 to 2.5 mm long. Flowers axillary, one or two in each axil opening at the same time, their pedicels 2 to 3 mm long. Pistillate perianth segments 6, oblong-obovate to oblong-spatulate, 2 to 2.5 mm long, obtuse. Ovary about 1 mm high, glabrous, the style cylindric, not constricted below, continuous with and as wide as the ovary, about 1.8 mm long and 1.2 mm in diameter. Staminate flowers few, their anthers 3, about 1 mm long. Fruits depressed-globose, about 8 mm in diameter, obscurely sulcate, usually 3-celled, 6-seeded.

LUZON, Pangasinan Province, Mount San Isidro, Labrador, *Bur. Sci. 30059 Fénix*, November 13, 1917, on grassy and rocky slopes, altitude about 60 meters, with the Pampangan name *malapalin.*

A species well characterized by its small, strongly inequilateral, obtuse, falcate, pale leaves. In appearance it more nearly resembles *Glochidion triandrum* (Blanco) C. B. Rob. than any other Philippine species, but differs totally from that form in its style characters.

GLOCHIDION BRACHYSTYLUM sp. nov. § *Hemiglochidion.*

Frutex vel arbor parva, monoica, ramis hirsutis, valde elongatis; foliis chartaceis, oblongis, tenuiter acuminatis, glabris, usque ad 25 cm longis, nervis utrinque circiter 10, supra impressis, subtus valde prominulis, floribus ♂ longe et tenuiter pedicellatis, sepalis oblongis, 3 mm longis, ♀ breviter pedicellatis, perianthii segmentis recurvatis, utrinque hirsutis; ovario pubescente, columna stylari crassa cylindrica, pubescens, circiter 1 mm diametro, truncata, quam ovario paullo longioribus.

A shrub or small tree, the ultimate branches greatly elongated, spreading-hirsute with short, stiff, dark-brown hairs. Leaves chartaceous, oblong, slenderly acuminate, base rounded to subacute, 20 to 25 cm long, 7 to 8 cm wide, brownish-olivaceous and shining when dry; lateral nerves about 10 on each side of the midrib, impressed on the upper surface, very prominent on the lower surface, curved, anastomosing, the reticulations lax, prominent; petioles about 5 mm long. Staminate flowers up to 25 in a fascicle, their pedicels slender, sparingly spreading-hirsute, 10 to 12 mm long. Perianth segments oblong, 3 mm long, glabrous or the outer ones with a very few, short, spreading hairs. Anthers 3, united, about 1 mm long. Pistillate flowers axillary, fascicled, on the more distal parts of the same branches bearing the staminate ones, 5 to 20 in a fascicle, their pedicels hirsute, about 2 mm long. Perianth segments oblong, recurved, 3 mm long, spreading-hirsute on both surfaces. Ovary pubescent, about 10-celled.

shorter than wide; stylar column cylindric, entire, not contracted at the base, nearly as wide as the ovary, pubescent, about 1 mm long and wide, truncate, hollow.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 31374 Ramos & Edaño,* May 22, 1918, in forests along small streams.

In leaf venation this species resembles *Glochidion dolichostylum* Merr. but differs radically from that species in its longer, slenderly acuminate, more numerously nerved, glabrous leaves, and is entirely different in its floral characters.

GLOCHIDION HUMILE sp. nov. § *Hemiglochidion.*

Frutex parvus, ramis usque ad 30 cm longis e radicibus incrassatis; foliis ellipticis, subcoriaceis, 4 ad 10 cm longis, utrinque plerumque rotundatis, nervis utrinque circiter 6, cum reticulis perspicuis, subtus ad costa nervisque pubescens; floribus fasciculatis, ♂ tenuiter pedicellatis, perianthii segmentis ellipticis, 3 mm longis, exterioribus pubescens; staminibus 3; floribus ♀ breviter pedicellatis, pubescens, ovario pubescente, columna stylari pubescente, quam ovario duplo longiore, cylindrica, sursum leviter angustata, basi haud constricta.

A shrub or undershrub consisting of short, simple branches produced from the much-thickened roots, these branches varying in length from 7 to 30 cm, slender, terete, up to 3 mm in diameter, the older ones glabrous, the younger parts pubescent. Leaves elliptic to somewhat oblong-elliptic, subcoriaceous, 4 to 10 cm long, 2.5 to 5 cm wide, base rounded, apex usually rounded, sometimes obtuse, the upper surface glabrous or nearly so, usually pale when dry, the lower surface distinctly pubescent on the midrib, nerves, and reticulations; lateral nerves about 6 on each side of the midrib, distinct, the reticulations lax, evident. Male and female flowers fascicled, mostly in separate axils, male flowers with pedicels up to 11 mm long, slightly pubescent, the outer three perianth-segments elliptic, obtuse, about 3 mm long, somewhat pubescent, the inner three somewhat smaller, glabrous or slightly pubescent on the medium portion. Stamens 3, the staminal mass cylindric, about 1.5 mm long. Female flowers with pedicels about 3 mm long, pubescent. Sepals oblong to narrowly oblong, obtuse, pubescent, 2 mm long. Ovary and style pubescent, the styles forming an almost entire or slightly lobed column which is nearly as broad as the ovary, not at all constricted at the base, slightly narrowed upward, and about twice as long as the ovary. Capsules usually about 8-celled, depressed-globose, prominently sulcate, about 1.3 cm in diameter, brown when dry, sparingly pubescent with short hairs.

MINDANAO, Bukidnon Subprovince, near Tanculan, *Bur. Sci. 26112 Fénix*, July 17, 1916, in open grasslands.

This species is apparently dwarfed due to its habitat. Like several forms in other genera which occur in open cogon areas, the root becomes more or less thickened and produces few to many shoots which endure but one or two years, as all but the subterranean parts of the individual plants are destroyed by the annual grass fires. In habit it is quite different from any other species known to me.

GLOCHIDION CAULIFLORUM sp. nov. § *Euglochidion.*

Arbor parva; foliis subcoriaceis, oblongis ad oblongo-ovatis, usque ad 25 cm longis, plus minusve pubescens vel vetustioribus subglabris, breviter acuminatis, basi latissime et abrupte subtruncato-rotundatis admodum leviter cordatis, nervis utrinque 9 ad 11, perspicuis; inflorescentiis caulinis, racemosis, racemis solitariis vel fasciculatis, 3 ad 12 cm longis, floribus fasciculatis, floribus ♂ campanulatis, circiter 4 mm longis, segmentis parcissime ciliatis, staminibus 5; fructibus obovoideis, 10- ad 12-locellatis, circiter 3 cm longis, leviter pubescens, valvis sublignosis.

A small tree 5 to 6 m high, the younger branches densely pubescent. Leaves subcoriaceous, oblong to oblong-ovate, 13 to 25 cm long, 5 to 9 cm wide, the apex shortly acuminate, the base broadly and abruptly rounded, sometimes shallowly cordate, brownish or olivaceous when dry, more or less pubescent on both surfaces or in age the upper surface nearly glabrous; lateral nerves 9 to 11 on each side of the midrib, prominent, the reticulations very distinct on the lower surface; petioles stout, up to 4 mm in length. Inflorescence from the trunk and perhaps from the larger branches, solitary or two or three from a tubercle, racemose, 3 to 12 cm long, pubescent, the male and female flowers borne on the same raceme, fascicled at the leafless nodes of the racemes. Pedicels of the male flowers 5 to 6 mm long, glabrous or very slightly ciliate, the perianth campanulate, about 4 mm long, the lobes elliptic or elliptic-ovate, obtuse, sparingly ciliate with few, long, scattered, spreading hairs. Stamens 5, the staminal mass ellipsoid including the somewhat produced connectives, about 1.7 mm long. Female flowers apparently few, sometimes in separate inflorescences, sometimes in the same fascicles with the male flowers. Sepals oblong-lanceolate, pubescent, about 3.5 mm long and somewhat accrescent. Fruit obovoid, 10- to 12-celled, about 3 cm long, white when fresh, somewhat pubescent, when mature the valves somewhat woody.

MINDANAO, Lanao District, near Camp Vickers, *For. Bur. 25183 Alvarez* (type), March 17, 1916, in dipterocarp forests, altitude about 900 meters. LEYTE, Dagami, *Bur. Sci. 15352 Ramos,* August 12, 1912, said to be from the mossy forest, Mount Buraui.

Both specimens cited above were originally identified by me as *Glochidion weberi* C. B. Rob., as they distinctly resemble the latter species in vegetative characters. The most remarkable character of the present species and one that distinguishes it from all representatives of the genus known to me is its cauline, solitary or fascicled, racemose inflorescence, the racemes varying in length from 3 to 12 cm and having the flowers either solitary or fascicled at their leafless nodes.

APOROSA Blume

APOROSA ACUMINATISSIMA sp. nov.

Arbor glabra, circiter 7 m alta; foliis subcoriaceis, lanceolatis, tenuiter caudato-acuminatis, integris, usque ad 10 cm longis, pallide olivaceis, nitidis, nervis utrinque circiter 5, distinctis, anastomosantibus, adscendentibus; infructescentiis axillaribus et e axillis defoliatis, racemosis, 2 ad 4 cm longis, glabris vel parcissime pubescentibus; fructibus ovoideis vel ellipsoideo-ovoideis, circiter 1 cm longis.

A glabrous tree about 7 m high, the branches and branchlets reddish-brown, slender. Leaves lanceolate, subcoriaceous, pale-olivaceous when dry, somewhat shining, 6 to 10 cm long, 1.5 to 3 cm wide, base acute or acuminate, apex slenderly caudate-acuminate, the acumen usually falcate, margins entire; lateral nerves about 5 on each side of the midrib, slender, distinct, ascending, anastomosing; petioles about 5 mm long; stipules none or minute and caducous. Fruiting racemes axillary and from the axils of fallen leaves, solitary, 2 to 4 cm long, glabrous or very slightly pubescent, each with from two to five fruits; fruits ovoid or ellipsoid-ovoid, about 1 cm long, pale-brownish when dry; stigmas 2.

LUZON, Laguna Province, Cavinti, Palasan, *For. Bur. 26185 Amarillas,* September 9, 1916, on forested slopes, altitude about 465 meters.

A species similar, and manifestly allied, to *Aporosa sphaeridophora* Merr., from which it is readily distinguished by its much narrower, lanceolate, prominently caudate-acuminate leaves.

APOROSA STIPULOSA sp. nov.

Arbor, inflorescentiis exceptis glabra; foliis coriaceis, oblongis vel late oblongo-lanceolatis, nitidis, apice acuminatis, basi rotundatis et leviter cordatis, usque ad 24 cm longis; stipulis usque ad 3 cm longis, late falcato-acinaciformibus, acuminatis; spicis ♂ fasciculatis, sessilibus vel breviter pedunculatis, 1 ad 2 cm longis, cylindraceis, floribus sessilibus, staminibus 2 vel 3; inflorescentiis masculinis axillaribus, fasciculatis, floribus 5-meris, racemose dispositis; ovario vestito.

A tree, glabrous or nearly glabrous except the inflorescences. Branches stout, terete, dark colored when dry. Leaves oblong to broadly oblong-lanceolate, 15 to 24 cm long, 5 to 6 cm wide, coriaceous, shining, the base rounded, slightly cordate, the apex prominently acuminate; nerves about 14 on each side of the midrib, very prominent beneath, curved-ascending, anastomosing, the reticulations rather dense, distinct; petioles 1 to 1.5 cm long, pubescent when young, ultimately glabrous; stipules of the same texture as the leaves, large and prominent, broadly falcate-acinaciform, 2 to 3 cm long, the base broad and rounded, the apex acuminate. Staminate inflorescences fasciculate, the flowers arranged in dense cylindric spikes 1 to 2 cm long, which are sessile or very shortly peduncled, their rachises pubescent. Calyx segments 3 or 4, slightly pubescent; stamens 2 or 3, their filaments 2 mm long. Pistillate inflorescences axillary, fascicled, the flowers 5-merous, racemosely arranged, the rachis densely fulvous-pubescent, about 2.5 cm long; pedicels stout, about 1.5 mm long, each subtended by a small, ovate bracteole. Ovary densely fulvous-pubescent. Fruit narrowly ovoid, glabrous, narrowed upward, 1.5 cm long.

BILIRAN, *Bur. Sci. 18642 McGregor*, June, 1914. LEYTE, *Wenzel 637*, March, 1917. MINDANAO, Agusan Province, *Elmer 13474, 14042*, August and October, 1912: Lanao District, *Mrs. Clemens 968* (type), March and May, 1907, *For. Bur. 22029 Sherfesee, Cenabre & Ponce*, April, 1914. In forests at low altitudes, ascending to 800 meters.

This species belongs in the group with *Aporosa lunata* Kurz, *A. benthamiana* Hook. f., and *A. falcifera* Hook. f. together with three Bornean species, *A. hosei* Merr., *A. grandistipula* Merr., and *A. euphlebia* Merr. It seems to be closest, however, to a Celebes form represented by *Koorders 16801* and identified by him, with doubt, as representing *Antidesma auriculatum* Teysm. & Binn. I have not been able to locate any published description of the latter, but in any case *Koorders 16801* is safely an *Aporosa*, not an *Antidesma.*

ANTIDESMA Burman

ANTIDESMA IMPRESSINERVE sp. nov.

Frutex vel arbor parva, partibus junioribus inflorescentiisque exceptis glaber; foliis chartaceis, oblongis ad elliptico-oblongis, usque ad 30 cm longis, tenuiter subcaudato-acuminatis, nervis utrinque circiter 18, supra cum reti venarum impressis, subtus valde prominulis; inflorescentiis ♀ et ♂ spicatis, simplicibus, tenuibus, valde elongatis, ♀ usque ad 50 cm longis, floribus 5-meris, dispersis; ovario dense pubescente; stylis terminalibus; fructibus oblique ovatis, leviter compressis, valde reticulato-rugosis, circiter 7.5 mm longis, breviter pedicellatis.

A shrub or small tree, glabrous except the very young parts and inflorescences. Leaves chartaceous, oblong to elliptic-oblong, 18 to 30 cm long, 7 to 10 cm wide, brownish or olivaceous and shining when dry, the base rounded to obtuse, apex slenderly subcaudate-acuminate and long-apiculate, the nerves and reticulations impressed on the upper surface, very prominent on the lower surface; lateral nerves about 18 on each side of the midrib, arched-anastomosing, the reticulations lax, distinct; petioles 5 to 8 mm long, glabrous; stipules narrowly lanceolate, long-acuminate, pubescent, 1 to 1.5 cm long. Staminate spikes axillary, solitary or in pairs, slender, densely ferruginous-pubescent, up to 20 cm long, the flowers widely scattered, sessile, about 2 mm in diameter, their subtending bracteoles pubescent, oblong-ovate, about 0.8 mm long. Calyx lobes usually 5, oblong-ovate, pubescent, 1 mm long, free nearly to the base. Disk glabrous. Stamens usually 4, their filaments 1 mm long. Pistillate inflorescences very slender, apparently pendulous, up to 50 cm long, more or less pubescent, the lower part naked, the upper part with usually widely scattered sessile flowers. Calyx lobes ovate, about as large as those of the staminate flowers. Ovary ovoid, densely ferruginous-pubescent; stigmas three, terminal, about 1 mm long, cleft nearly to the middle. Fruits obliquely ovate, somewhat compressed, base rounded, 7 to 8 mm long, 6 mm wide, prominently reticulate-rugose when dry, slightly pubescent when young, soon becoming glabrous; styles terminal.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 31409* (type), *31268, 31020 Ramos & Edaño,* April and May, 1918, in forests along small streams.

This species is manifestly allied to *Antidesma cumingii* Muell.-

Arg. from which it is at once distinguished by its conspicuously impressed nerves and reticulations, and by its very slender, greatly elongated inflorescences, both the staminate and pistillate flowers even in young inflorescences being widely scattered and not densely crowded as in *A. cumingii.*

ANTIDESMA ILOCANUM sp. nov.

Frutex vel arbor parva, ramulis inflorescentiisque castaneopubescentibus; foliis lanceolatis, chartaceis, 15 ad 20 cm longis, subtus ad costa nervisque leviter pubescentibus, acuminatis, basi plerumque obtusis, nervis utrinque circiter 12, perspicuis; stipulis linearis vel lineari-lanceolatis, 6 ad 8 mm longis; racemis ♀ axillaribus, solitariis, circiter 20 cm longis; fructibus inaequilateraliter ovoideis, glabris, 9 mm longis, obtusis, stigmate terminale.

A shrub or small tree, the young branchlets and inflorescences castaneous-pubescent. Leaves lanceolate, chartaceous, 15 to 20 cm long, 3 to 4.5 cm wide, pale-olivaceous and shining when dry, the lower surface brownish and sparingly castaneous-pubescent on the midrib and nerves, ultimately glabrous or nearly so, somewhat narrowed upward to the acuminate apex, the acumen with a short mucro, base slightly narrowed, rounded to obtuse; lateral nerves about 12 on each side of the midrib, prominent on the lower surface, arched, anastomosing, the reticulations distinct; petioles stout, 5 to 7 mm long, when young castaneous-pubescent, soon becoming glabrous; stipules linear or linear-lanceolate, acuminate, 6 to 8 mm long. Pistillate racemes axillary, simple, about 20 cm long, the rachis rather stout, castaneous-pubescent, marked with numerous scars of fallen pedicels, the pedicels pubescent, 2 to 3 mm long. Sepals 5, pubescent, about 1 mm long. Fruits ovoid, inequilateral, glabrous, somewhat compressed, about 9 mm long, the base broadly rounded, apex obtuse, when dry prominently reticulate-rugose; stigmas terminal.

LUZON, Ilocos Norte Province, between Bangui and Claveria, *Bur. Sci. 32998 Ramos*, August 12, 1918, in thickets and forests at low altitudes.

The alliance of this species is manifestly with *Antidesma cumingii* Muell.-Arg., from which it is readily distinguished by its relatively much-narrowed leaves and its very narrow stipules.

ANTIDESMA CATANDUANENSE sp. nov.

Arbor parva, inflorescentiis parce pubescentibus exceptis glabra; ramis ramulisque griseis, teretibus; foliis chartaceis, ellipticis, usque ad 11 cm longis et 7 cm latis, breviter acuminatis, basi

acutis ad subrotundatis, supra olivaceis, nitidis, subtus pallidioribus, nervis utrinque 5, perspicuis, reticulis laxis, distinctis; infructescentiis axillaribus terminalibusque, usque ad 5 cm longis, breviter pedunculatis vel e basi ramosis, tri- vel quadripinnatim paniculatis, multifloris; fructibus subovoideis, racemose dispositis, leviter inaequilateralibus, in siccitate nigris, leviter reticulatis, circiter 3 mm longis, stigmate terminale; calycis subulatis, truncatis.

A small tree, 6 m high fide Ramos, entirely glabrous except the sparingly pubescent infructescences. Branches and branchlets smooth, terete, gray. Leaves chartaceous, olivaceous and shining when dry, the lower surface paler than the upper, elliptic, 8 to 11 cm long, 4.5 to 7 cm wide, the apex rather abruptly and shortly acuminate, base rounded to acute; primary lateral nerves 5 on each side of the midrib, rather prominent on the lower surface, curved and somewhat ascending, anastomosing, the reticulations distinct, rather lax; petioles 1 to 1.5 cm long. Infructescences axillary and terminal, shortly peduncled or branched from the base, tri- or quadripinnately paniculate, many flowered, up to 5 cm in length. Fruits racemosely disposed on the ultimate branchlets, subovoid, slightly compressed, black when dry, somewhat rugose, about 3 mm long, slightly inequilateral, the stigmas terminal; pedicels 1.5 to 2 mm long, the subtending bracteoles 0.5 mm long or less. Persistent calyx cup-shaped, about 1 mm long and wide, truncate.

CATANDUANES, Mount Mariguidon, along streams in forests, *Bur. Sci. 30515 Ramos*, November 13, 1917.

This species is well characterized by its elliptic, shortly and rather abruptly acuminate, few-nerved leaves, and its many-flowered paniculate inflorescences. It is perhaps as closely allied to *Antidesma microcarpum* Elm. as to any other species.

ANTIDESMA SANTOSII sp. nov.

Arbor parva, subglabra; foliis oblongo-ellipticis, olivaceis, nitidis, usque ad 12 cm longis, caudato-acuminatis, basi acutis, nervis utrinque 7 vel 8, subtus perspicuis, obliquis; infructescentiis terminalibus, pauciramosis, 5 ad 6 cm longis, leviter griseo-puberulis; fructibus pedicellatis, oblongo-ellipticis, utrinque acutis vel leviter acuminatis, aequilateralibus, leviter compressis, glabris, in siccitate reticulatis.

A small tree about 7 m high, subglabrous, or the younger parts sparingly pubescent. Branches grayish-brown, terete, smooth. Leaves chartaceous, oblong-elliptic, olivaceous, shining, subequally narrowed to the acute base and to the prominently

subcaudate-acuminate apex, the acumen blunt, up to 2 cm in length, sparingly pubescent on the midrib on both surfaces or ultimately glabrous; lateral nerves 7 or 8 on each side of the midrib, prominent on the lower surface, anastomosing, ascending; petioles about 1 cm long; stipules apparently minute, caducous. Infructescences terminal, 5 to 6 cm long, sparingly grayish-puberulent, usually with 2 or 3 branches, the branches 3 to 4 cm long. Fruits racemosely arranged, their pedicels 1 to 1.5 mm long, the subtending bracteoles ovate, acute, somewhat pubescent, 0.6 mm long, the fruits brown when dry, shining, glabrous, rugose, oblong-ellipsoid, equilateral, about 4 mm long, subequally narrowed to the acute or slightly acuminate base and apex, the stigma terminal. Calyx cup-shaped, about 1.2 mm long, the teeth 4, broad, shallow, obtuse, somewhat ciliate.

LUZON, Laguna Province, Mount Banahao, *For. Bur. 26300 Santos*, August 28, 1916, on slopes along small streams, altitude about 600 meters.

A species well characterized by its obliquely nerved, subcaudate-acuminate leaves; its branched inflorescences; racemosely arranged, shining, equilateral, 4 mm long, glabrous fruits; and 4-merous flowers. It is apparently most closely allied to *Antidesma obliquinervium* Merr., of Palawan, but is at once distinguished from it by its much longer petioles.

ANTIDESMA MEGALOPHYLLUM sp. nov.

Species *A. cumingii* affinis, differt foliis majoribus, usque ad 33 cm longis et 13 cm latis, stipulis longioribus, circiter 2.5 cm longis, et fructibus majoribus, circiter 13 mm longis.

A tree about 7 m high, glabrous except the younger branchlets. Branches terete, brownish, smooth, glabrous. Leaves firmly chartaceous, oblong to oblong-elliptic, 20 to 33 cm long, 9 to 13 cm wide, base rounded, cordate, apex usually prominently acuminate, entirely glabrous or when young sparingly pubescent on the midrib beneath, subolivaceous, shining and of about the same color on both surfaces when dry; lateral nerves about 15 on each side of the midrib, prominent, arched-anastomosing, the reticulations lax; petioles stout, 5 to 10 mm long, pubescent when young, ultimately glabrous; stipules linear-lanceolate, slightly falcate, acuminate, about 2.5 cm long and 3 mm wide. Pistillate racemes greatly elongated in fruit, pendulous, 30 to 40 cm in length, bearing fruit only in the upper part, the rachis and peduncle sparingly pubescent. Fruits strongly inequilateral, ovoid, obtuse, rounded at the base, prominently and laxly reticulate-rugose, glabrous, pale and somewhat shining when dry, about 13 mm long and 1 cm wide, the pedicels about 5 mm long; persistent calyx-lobes 5, lanceolate, acuminate, pubescent, about 1.5 mm long.

BABUYAN ISLANDS, Calayan, *For. Bur. 26642 Velasco*, June 6, 1917, in forests, altitude about 40 meters.

A species manifestly closely allied to *Antidesma cumingii* Muell.-Arg., differing in its larger leaves, longer stipules, and larger fruits.

DAPHNIPHYLLUM Blume

DAPHNIPHYLLUM OBTUSIFOLIUM sp. nov.

Frutex glaber, ramulis brunneis, laevis, teretibus; foliis ellipticis ad oblongo-ellipticis, coriaceis, usque ad 9 cm longis, in siccitate nitidis, utrinque olivaceis et concoloribus vel subtus admodum brunneis, apice late rotundatis, interdum brevissime apiculatis, nervis utrinque 6 ad 9, distinctis; infructescentiis circiter 5 cm longis, fructibus ovoideis, laevis, in siccitate nigris, circiter 12 mm longis.

A glabrous shrub about 3 m high, the branches terete, brownish, slightly wrinkled, the branchlets smooth, brown or reddish-brown. Leaves numerous, elliptic to oblong-elliptic, 6 to 9 cm long, 3 to 4 cm wide, olivaceous and shining on both surfaces when dry, coriaceous, usually of the same color beneath as above, sometimes somewhat brownish, never glaucous, entire, the apex broadly rounded and sometimes minutely apiculate, base acute and obscurely 3-nerved or 3-plinerved; lateral nerves 6 to 9 on each side of the midrib, somewhat curved, distinct on both surfaces as are the reticulations; petioles brown, 2.5 to 3.5 cm long. Infructescences axillary, about 5 cm long. Fruits ovoid, black, somewhat fleshy, about 12 mm long, the pericarp somewhat wrinkled when dry, the styles less than 1 mm long, spreading or recurved.

LUZON, Tayabas Province, Mount Binuang, *Bur. Sci. 28705* (type), *28662 Ramos & Edaño*, May, 1917, in forests near the summit of the mountain, altitude about 1,000 meters.

This species is perhaps as closely allied to *Daphniphyllum glaucescens* Blume as to any other species, but is readily distinguished by its leaves being broadly rounded at their apices, not acuminate, but at most minutely apiculate. It likewise differs from *Daphniphyllum borneense* Stapf in the same leaf characters and in having much longer petioles.

AGROSTISTACHYS Dalzell

AGROSTISTACHYS LEPTOSTACHYA Pax & K. Hoffm. in Engl. Pflanzenreich 57 (1912) 102.

LUZON, Camarines Province, Paracale, *Bur. Sci. 33688 Ramos & Edaño,* November 30, 1918, in forests near small streams at low altitudes.

This species has previously been known only from Borneo. The Philippine material is an exact match for our series of Bornean specimens including *Hose 162*, cited in the original description.

CLAOXYLON Jussieu

CLAOXYLON ELLIPTICUM sp. nov. § *Indica.*

Frutex vel arbor parva, ramulis inflorescentiisque adpresse hirsutis; foliis ellipticis, chartaceis, usque ad 14 cm longis, basi rotundatis ad subobtusis, apice abrupte acuminatis, nervis utrinque 5, subtus valde prominulis, margine minute et distanter glanduloso-denticulatis; inflorescentiis ♂ axillaribus solitariis, petiolo subaequantibus; floribus circiter 7 mm diametro; staminibus circiter 30, glandulis elongatis, oblongis, supra perspicue albido-ciliatis.

A shrub or small tree, the branches and inflorescences rather prominently appressed-hirsute, the indumentum on the younger parts fulvous. Leaves chartaceous, elliptic to oblong-elliptic, 9 to 14 cm long, 4.5 to 7.5 cm wide, base rounded to subobtuse, apex rather abruptly acuminate, the acumen broad, acute, margins distantly and minutely glandular-serrulate, greenish-olivaceous when dry, shining, both surfaces minutely papillate-scaberulous; lateral nerves 5 on each side of the midrib, curved-ascending, arched-anastomosing, very prominent, primary nerves and larger reticulations more or less pubescent; petioles 1.5 to 3 cm long, appressed-pubescent, eglandular. Staminate inflorescences axillary, solitary, equaling or shorter than the petioles, simple, flowers white, short-pedicelled, in bud fulvous-hirsute as are other parts of the inflorescences. Flowers about 7 mm in diameter. Sepals 3, oblong-obovate, narrowed below, 4 to 5 mm long. Stamens about 30; filaments 2.5 mm long, glabrous, the interstaminal glands narrowly oblong, 2 mm long, conspicuously ciliate at their apices, the cilia white, about 1 mm long.

PANAY, Antique Province, Culasi, *Bur. Sci. 32303 McGregor,* May 18, 1918, on forested slopes, altitude 800 meters.

This species belongs in the group with *Claoxylon longifolium* Miq. and *C. subviride* Elm. and is distinctly more closely allied to the latter, from which it differs in its very minutely glandular-serrulate leaves, eglandular petioles and much fewer stamens. In this connection I am of the opinion that all of the Philippine specimens referred by Pax to *C. longifolium* are referable to *C. subviride* on account of their short inflorescences and their biglandular petioles.

BLUMEODENDRON (Muell.-Arg.) Kurz

This group was first characterized by Muell.-Arg. in 1866 as a subgenus of *Mallotus*, and raised by Kurz to generic rank in 1873, although Bentham and Hooker f. retained it as a subgenus of *Mallotus* as originally placed by Mueller. The type is the Javan species originally described by Blume as *Elateriospermum tokbrai* Blume. J. J. Smith[2] has justly reinstated the group as of generic rank, in which he has been followed by Pax.[3] The two known Malayan species are *Blumeodendron tokbrai* (Blume) Kurz (quoad syn. Blume) and *B. kurzii* (Hook. f.) J. J. Sm.; the former known from Java and Borneo, the latter from Tenasserim, the Andaman Islands, Malay Peninsula, Sumatra, and Java. *Blumeodendron kurzii* J. J. Sm. is the form thought by Kurz to represent *Elateriospermum tokbrai* Blume, and which was later redescribed by Hooker f. as *Mallotus kurzii*. To this genus in 1912 I referred the Philippine species described two years earlier by Mr. Elmer as *Sapium rotundifolium*.

In a note prepared at Kew and supplied to me in 1911 by the late Dr. C. B. Robinson he indicates that both he and Mr. R. A. Rolfe were of the opinion that the Kew material from the Indo-Malayan region then available represented at least four distinct species. In the Philippines I find the genus to be represented by at least five distinct species, and possibly by seven, as a sterile specimen from Leyte is somewhat different from the forms enumerated below, while two fruiting specimens from Basilan, *Bur. Sci. 16138 Reillo* and *For. Bur. 18906 Miranda* can scarcely be referred to described species. The genus *Blumeodendron* is then considerably larger than the current literature would indicate.

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[2] Meded. Dept. Landbouw 10 (1910) 460.

[3] Engl. Pflanzenreich 63 (1914) 47.

Key to the Philippine species of Blumeodendron.

a^1. Fruits globose or subglobose, terete, not compressed or angled.
  b^1. Reticulations conspicuous.......... 1. B. paucinervium.
  b^2. Reticulations not conspicuous.
    c^1. Leaves mostly alternate.
      d^1. Staminate and pistillate inflorescences axillary, peduncled, the flowers subumbellately arranged.......... 2. B. philippinense.
      d^2. Flowers solitary or fascicled, chiefly on leafless branches and on the trunks.......... 3. B. subcaudatum.
    c^2. Leaves all verticillate; flowers fascicled in the axils of fallen leaves, on the larger branches, and on the trunks.......... 4. B. verticillatum.
a^2. Fruits conspicuously compressed and keeled, or distinctly 3-angled, borne on tubercles along the larger branches and on the trunks. 5. B. subrotundifolium.

1. BLUMEODENDRON PAUCINERVIUM (Elm.) comb. nov.

Elateriospermum paucinervium Elm. Leafl. Philip. Bot. 2 (1908) 484; Pax in Engl. Pflanzenreich 44 (1910) 102.

LUZON, Tayabas Province, Mount Banahao, *Elmer 7416*, (type), May, 1906: Bataan Province, Mount Mariveles, *For. Bur. 758 Borden*, May, 1904. SIBUYAN, *Elmer 12367*, April, 1910, in primary forests.

Of this species fruiting specimens only are known, yet I am now convinced that it is referable to *Blumeodendron*, and among the known species of this genus that it is most closely allied to *B. tokbrai* (Blume) Kurz. I had previously[4] expressed the opinion that it might be referable to *Cheilosa* or *Alcinaeanthus*. It is distinguished from the other Philippine species of *Blumeodendron* by the prominently reticulate leaves, in this character resembling *B. tokbrai* (Bl.) Kurz, of which I now have seven specimens from Java available for comparison.

2. BLUMEODENDRON PHILIPPINENSE Merr. & Rolfe sp. nov.

Arbor glabra, usque ad 25 m alta; foliis alternis, vel superioribus rariter verticillatis, coriaceis, in siccitate brunneis, nitidis, oblongis ad oblongo-ellipticis, 8 ad 20 cm longis, basi plerumque acutis, apice perspicue acuminatis, nervis utrinque 6 vel 7, adscendentibus, perspicuis; inflorescentiis axillaribus, ♂ fasciculatis, 1 ad 1.5 cm longis, floribus subumbellatim dispositis, staminibus circiter 35, ♀ plerumque solitariis, pedunculatis, floribus 4 vel 5; capsulis subglobosis, 3 ad 4 cm diametro, 1- vel 2-locellatis, seminibus 1 vel 2.

A glabrous tree, up to 25 m high, branchlets brownish.

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[4] Philip. Journ. Sci. 7 (1912) Bot. 382.

Leaves all alternate, or the uppermost ones occasionally opposite or rarely in whorls of 3, coriaceous, usually brownish when dry, oblong to oblong-elliptic, 8 to 20 cm long, 4 to 10 cm wide, the base acute, sometimes rounded, the apex rather abruptly and conspicuously acuminate, the acumen 1 to 2 cm long; lateral nerves usually 6 or 7 on each side of the midrib, prominent, ascending, the reticulations slender, subparallel, not prominent; petioles 3 to 7 cm long. Staminate inflorescences, axillary, fascicled, 1 to 1.5 cm long, the flowers subumbellately arranged near the apices of the peduncles, the buds globose, glutinous, the pedicels up to 8 m long. Sepals 3, elliptic-ovate, obtuse, 4.5 mm long. Stamens about 35, the filaments up to 4 mm long. Pistillate inflorescences axillary, usually solitary, 1 to 1.5 cm long, the flowers usually 4 or 5, subumbellate, the pedicels stout, 2 to 3 m long. Calyx 1.5 to 2 mm long, 3- or 4-toothed. Ovary narrowly ovoid, 2-celled; style very short; stigmas 2, stout, recurved. Fruit globose, usually 1- or 2-seeded, 3 to 4 cm in diameter, the pericarp brown, rather brittle, ultimately dehiscent, the sutures obscure.

LUZON, Bataan Province, Mount Mariveles, *For. Bur. 630, 2377 Borden, For. Bur. 2401 Meyer, For. Bur. 7511, 7228 Curran, For. Bur. 12962 Alvarez, For. Bur. 20054 Topacio* (type), *For. Bur. 24782 Sulit, Williams 699, Whitford 339:* Laguna Province, San Antonio, *Bur. Sci. 16549 Ramos*, pistillate flowers. In primary forests at low altitudes, ascending to 700 meters, flowering in January, September, and October.

Although much of the material representing this species was collected between the years 1903 and 1905 no description of it has yet been published. Female flowers were not secured until 1912 and from the staminate flowers and fruits it was impossible for me to place it in its proper genus in Manila. In November, 1911, Dr. C. B. Robinson and Mr. R. A. Rolfe made a critical examination of the Philippine material available in the Kew Herbarium, resulting in Mr. Rolfe's placing the species in the genus *Blumeodendron.* In a note supplied by Doctor Robinson at that time he intimated that both he and Mr. Rolfe were in agreement that four distinct species were represented by the Indian and Malayan material then available at Kew. The present species I believe to be most closely allied to *Blumeodendron kurzii* J. J. Sm., of the Andaman Islands, Tenasserim, Malay Peninsula, and Java.

3. **BLUMEODENDRON SUBCAUDATUM** sp. nov.

Arbor glabra, usque ad 25 m alta; foliis omnibus alternis, coriaceis, ellipticis ad elliptico-ovatis, nitidis, in siccitate brunneis vel brunneo-olivaceis, 8 ad 12 cm longis, subcaudato-acuminatis, nervis utrinque plerumque 4, tenuibus, reticulis obscuris. Floribus ♂ solitariis vel fasciculatis, plerumque in ramis defoliatis dispositis, staminibus circiter 35; capsulis solitariis, lateralibus, subglobosis, 3 ad 3.5 cm diametro, obscure 2-valvis, seminibus 1 vel 2.

A glabrous tree, at least 25 m high, the branches brown or reddish-brown, shining. Leaves all alternate, coriaceous, elliptic-ovate, usually brownish or brownish-olivaceous when dry, shining, 8 to 12 cm long, 3.5 to 7 cm wide, the base usually rounded, the apex subcaudate-acuminate, the acumen slender, blunt, up to 2 cm long; lateral nerves usually 4 on each side of the midrib, rather slender, distinct, the reticulations not prominent, sometimes subobsolete; petioles 2.5 to 4 cm long. Staminate flowers solitary or fascicled, chiefly on the branches below the leaves, the buds globose, glutinous, their pedicels up to 8 mm long. Sepals 3, elliptic-ovate, obtuse, 4.5 mm long. Stamens about 35. Pistillate flowers unknown. Capsules ellipsoid or subglobose, solitary, on the branches below the leaves, 3 to 3.5 cm in diameter, ultimately 2-valved, the sutures obscure, 1- or 2-seeded, the pericarp brown, smooth, shining; stigmas 2.

LUZON, Sorsogon Province, *For. Bur. 10598 Curran,* June 16, 1908. SAMAR, *For. Bur. 21075* (type), *21069 Sherfesee, Cenabre & Cortes* (type), April, 1914, *Bur. Sci. 17407 Ramos,* April, 1914, *For. Bur. 24643 Phasis.* PANAY, Capiz Province, *For. Bur. 23928 Cortes & Knapp,* May, 1915. In primary forests at low altitudes, known in Samar as *sabunotan, dancalan,* and *salgnan,* and in Panay as *lindog.*

This species is distinguished from *Blumeodendron philippinense,* described above, by its constantly smaller, fewer-nerved, somewhat caudate-acuminate leaves and by its solitary or fascicled flowers, the rachises of the inflorescences not being at all produced. The field note with one of the Samar specimens cited above indicates that the flowers also grow along the trunk as well as on the branches.

4. **BLUMEODENDRON VERTICILLATUM** sp. nov.

Arbor glabra, usque ad 12 m alta; foliis omnibus verticillatis, coriaceis, subolivaceis vel pallidis, ellipticis ad obovato-ellipticis,

usque ad 15 cm longis, basi acutis, apice abrupte acuminatis, nervis utrinque 5 vel 6, distinctis, reticulis subtus distinctis; floribus ♂ axillaribus, fasciculatis, pedicellatis, resinosis, staminibus circiter 35. Capsulis globosis, 3 ad 3.5 cm diametro, tarde 2-valvis.

A glabrous tree up to 12 m high, the branches and branchlets terete, slender, internodes 6 to 10 cm long. Leaves all verticillate, 3 or 4 at each node, coriaceous, subolivaceous or pale when dry, slightly shining, elliptic to obovate-elliptic, 10 to 15 cm long, 5 to 8 cm wide, base acute, apex rather abruptly acuminate, the acumen blunt, up to 1 cm long; lateral nerves 5 or 6 on each side of the midrib, distinct, somewhat ascending, the reticulations rather lax, evident on the lower surface; petioles 2.5 to 3 cm long. Staminate flowers axillary, fascicled, mostly from leafless branches and on the trunk, the axis of the inflorescences not produced. Pedicels 4 to 5 mm long. Sepals 3, broadly ovate, rounded or obtuse, about 4 mm long. Stamens about 35. Buds globose, glutinous. Pistillate flowers unknown. Capsules globose, 3 to 3.5 cm in diameter, ultimately 2-valved, but the sutures scarcely visible on nearly mature fruits, the pericarp smooth, brown; stigmas 2, short, recurved.

LUZON, Bataan Province, Mount Mariveles, *For. Bur. 2603 Meyer*, February, 1905 (type), *For. Bur. 1190 Borden*, June, 1904, *For. Bur. 1515 Ahern's collector*, July, 1904, *Whitford s. n.* In primary forests, altitude about 600 meters.

A species characterized by its constantly verticillate leaves and fascicled flowers, the latter being for the most part borne at leafless nodes and on the trunk and larger branches.

5. **BLUMEODENDRON SUBROTUNDIFOLIUM** (Elm.) Merr. in Philip. Journ. Sci. 7 (1912) Bot. 384; Pax & Hoffm. in Engl. Pflanzenreich 63 (1914) 49.

Sapium subrotundifolium Elm. Leafl. Philip. Bot. 3 (1910) 930.

This species is as yet represented by only the type collection, *Elmer 12349* from Sibuyan, the specimen having very immature fruits. Pax and Hoffmann state regarding it: "species quoad genus incerta." To my mind there is not the slightest doubt that this species is properly placed as to the genus. It differs radically from the other described forms in its fruits being either compressed or 3-angled and further in their being borne on tubercles on the larger branches and apparently also on the trunks.

MALLOTUS Loureiro

MALLOTUS CONFUSUS sp. nov. § *Echinus.*

Mallotus barbatus Merr. in Philip. Journ. Sci. 7 (1912) Bot. 397, non Muell.-Arg.

Frutex dioicus, ad 7 m altus, ramulis junioribus densissime et molliter barbato-papillosis, papillae elongatae, stellato-tomentosae; foliis alternis, longe petiolatis, late ovatis, usque ad 36 cm longis, basi rotundatis, alte peltatis, apice perspicue caudato-acuminatis, margine irregulariter dentatis vel subintegris, subtus densissime griseo- ad ferrugineo-tomentosis; inflorescentiis ♂ circiter 20 cm longis, parce ramosis, floribus pedicellatis, ♀ pedunculatis, spiciformibus, densis, cylindraceis, 1 ad 1.5 cm diametro, floribus sessilibus; infructescentiis densis, cylindraceis, circiter 10 cm longis et 3.5 ad 4 cm diametro, capsulis echinis mollibus incurvis subulato-filiformibus stellato-tomentosis densissime obtectis.

A dioecious shrub up to 7 m in height, prominently stellate-tomentose. Branches terete, rather stout, 5 to 10 mm in diameter, the leaf-bearing parts densely covered with pale-brownish, soft, stout, densely stellate-tomentose papillae about 5 mm in length, the younger petioles often with similar papillae. Leaves alternate, broadly ovate, long-petioled, chartaceous, 13 to 36 cm long, 10 to 25 cm wide, the base broadly rounded and peltate, the petiole inserted 1.5 to 5 cm from the margin, the apex prominently caudate-acuminate, the margins subentire to irregularly dentate, the teeth never large, usually minute, the upper surface eventually glabrous, or the nerves somewhat stellate-tomentose, pale-olivaceous or brownish-olivaceous, the lower surface very densely stellate-tomentose with grayish to subferruginous, short hairs; petioles up to 18 cm in length, those of the smaller leaves very much shorter, sometimes but 3 to 4 cm in length, uniformly and densely stellate-tomentose, the younger ones with projecting stellate-tomentose papillae. Staminate inflorescences about 20 cm long, densely stellate-tomentose, sparingly branched, the branches 3 cm long or less. Pedicels about 3 mm long. Sepals 4, oblong-elliptic, 2.5 mm long. Stamens about 70, their filaments 2 mm long. Pistillate inflorescences solitary, simple, peduncled, the flower-bearing part dense, cylindric, spiciform, 4 to 5 cm long, 1 to 1.5 cm in diameter, the peduncles densely stellate-tomentose and often papillose. Calyx-lobes lanceolate, acuminate, 3 mm

long. Ovary densely tomentose; styles stout, densely bearded, about 4 mm long. Infructescences dense, cylindric, about 10 cm long and 3.5 to 4 cm in diameter, the individual capsules, including the thick indumentum, about 1.5 cm long, densely covered with filiform, densely stellate-tomentose, weak, variously incurved and intertwined, slender processes.

LUZON, Tayabas Province, Mount Tulaog, *Bur. Sci. 29153 Ramos & Edaño* (type), May, 1917; Atimonan, *Whitford 711*, August, 1904. SAMAR, Yabong, *Phil. Pl. 1650 Merrill*, March, 1914, with fruits. MINDANAO, Davao District, *DeVore & Hoover*, May, 1903.

The alliance of this species is manifestly with *Mallotus barbatus* Muell.-Arg., to which I previously referred *Whitford 711*, a specimen with pistillate flowers. Pax & Hoffmann[5] have already indicated that Whitford's specimen apparently represented a distinct species. Now that complete material is available, presenting staminate and pistillate flowers and fruits, it is clearly evident that this Philippine form is distinct from *Mallotus barbatus* Muell.-Arg.

MALLOTUS PAPUANUS (J. J. Sm.) Pax & K. Hoffm. in Engl. Pflanzenreich 63 (1914) 202.

Mallotus hookerianus Muell.-Arg. var. *papuanus* J. J. Sm. in Nova Guinea 8 (1912) 787, *t. 137*.

MINDANAO, Surigao Province, *Bur. Sci. 34549 Ramos & Pascasio*, April 30, 1919, in damp forests at low altitudes.

A species previously known only from New Guinea but scarcely distinguishable from *Mallotus hookerianus* Muell.-Arg. from southern China. The specimen is with mature fruits and agrees very closely with a cotype before me, *Gjellerup 316!*, staminate specimen.

MALLOTUS LONGISTYLUS sp. nov. § *Axenfeldia*.

Frutex vel arbor parva, glabra, vel partibus junioribus leviter pubescens; foliis alternis, oblongis, subcoriaceis, nitidis, penninerviis, eglandulosis, 25 ad 30 cm longis, basi rotundatis, apice tenuiter acuminatis, integris, nervis utrinque circiter 15; stipulis ovatis ad oblongo-ovatis, coriaceis, 7 ad 15 mm longis; racemis ♀ solitariis, circiter 10 cm longis, plerumque 3-floris, sepalis anguste lanceolatis, circiter 6 mm longis, capsulis subglobosis, leviter pubescens, haud glandulosis, spinis paucis tenuibus usque ad 2 mm longis, armatis.

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[5] Engl. Pflanzenreich 63 (1914) 165.

A nearly glabrous shrub or small tree, the branchlets terete, brownish, glabrous, about 2 mm in diameter, the very young parts slightly pubescent. Leaves alternate, oblong, subcoriaceous, shining, eglandular, 25 to 30 cm long, 6 to 8 cm wide, the base rounded, without glands, apex rather slenderly acuminate, margins entire; lateral nerves about 15 on each side of the midrib, curved, prominent; petioles 2 to 3 cm long, thickened at base and apex; stipules ovate to oblong-ovate, coriaceous, somewhat acuminate, 7 to 15 mm long, 5 to 8 mm wide, attached by their broad bases. Pistillate racemes solitary, leaf-opposed, slightly pubescent, about 10 cm long, usually about 3-flowered, the pedicels 5 mm long or less. Sepals narrowly lanceolate, acuminate, about 6 mm long, somewhat appressed-pubescent. Capsules subglobose, sparingly pubescent, not glandular, armed with rather slender, spreading, scattered spines up to 2 mm in length, the individual cocci about 7 mm in diameter; styles densely papillate, up to 4 cm in length.

DINAGAT, *Bur. Sci. 35173 Ramos & Pascasio*, May 11, 1919, in forests at low altitudes.

This characteristic species apparently belongs in the section *Axenfeldia* and is perhaps most closely allied to *Mallotus calvus* Pax & Hoffm. The elongated, entire, eglandular, alternate leaves, and the persistent, coriaceous stipules are characteristic.

WETRIA Baillon

WETRIA MACROPHYLLA (Blume) J. J. Sm. in Meded. Dept. Landbouw 10 (1910) 471; Pax & Hoffm. in Engl. Pflanzenreich 63 (1914) 219.

Trewia macrophylla Blume Bijdr. (1825) 612.

Wetria trewioides Baill. Étud. Gén. Euphorb. (1858) 409.

Pseudotrewia macrophylla Miq. Fl. Ind. Bat. 1^2 (1859) 414.

Alchornea blumeana Muell.-Arg. in Linnaea 34 (1865) 167, DC. Prodr. 15^2 (1866) 900.

Agrostistachys pubescens Merr. in Philip. Journ. Sci. 4 (1909) Bot. 274; Pax in Engl. Pflanzenreich 57 (1912) 99.

LUZON, Bataan Province, *For. Bur. 5940 Curran*, January, 1907, *For. Bur. 23450 Sherfesee & Alambra*, January, 1915. NEGROS, *For. Bur. 23871 Cardona*, April, 1915. BANCALAN, *Weber*, September, 1916. In bamboo thickets and in forests at low altitudes. A monotypic genus previously known from Borneo, Sumatra, and Java.

This species is a very characteristic one and, although our available Philippine material is all in fruit, I have not the slightest hesitancy in referring it to the Malayan *Wetria macrophylla* (Blume) J. J. Sm., it agreeing closely with our series of but the other specimens cited, including one from near the type of *Agrostistachys pubescens* Merr. has rather pubescent leaves, but the other specimens cited, including one from near the type locality, have glabrous or nearly glabrous leaves.

MACARANGA Thouars

MACARANGA OVATIFOLIA sp. nov.

Arbor parva, inflorescentiis ramulisque exceptis glabra, ramis circiter 1 cm diametro; foliis ovatis, chartaceis, integris, usque ad 25 cm longis, acuminatis, basi late rotundatis et distincte cordatis, subtus glandulosis, nervis utrinque 10 ad 12, perspicuis, petiolo usque ad 16 cm longo; infructescentiis lateralibus, paniculatis, solitariis, e axillis defoliatis, 6 ad 9 cm longis, pubescens; coccis solitariis, globosis, laevis, glabris, circiter 4 mm diametro.

A small tree, glabrous except the tips of the branchlets and the inflorescences, branches brown when dry, terete, the ultimate ones up to 1 cm in diameter, marked with large scattered petiolar scars, the leaf axils and the very tips of the branchlets ferruginous-pubescent. Leaves ovate, chartaceous, 20 to 25 cm long, 16 to 18 cm wide, entire, apex distinctly acuminate, base broadly rounded and distinctly cordate, the upper surface greenish-olivaceous, shining, the lower somewhat paler, with numerous pale-yellowish glands; lateral nerves 10 to 12 on each side of the midrib, prominent, the basal pair with about 10 secondary nerves on the lower side, the reticulations subparallel, distinct; petioles reddish brown, slender, up to 16 cm long. Infructescences paniculate, solitary, in the axils of fallen leaves, spreading, 6 to 9 cm long, ferruginous-pubescent, the branches few, the primary ones 4 cm long or less. Pedicels about 1.5 cm long, the bracteoles pubescent, oblong-obovate, somewhat toothed, up to 3 mm long. Fruit consisting of a single, globose, smooth, ultimately glabrous coccus, about 4 mm in diameter.

MINDANAO, Surigao Province, *Bur. Sci. 34583 Ramos & Pascasio*, June 15, 1919, along streams at low altitudes at the iron deposit on the northeast coast.

This species belongs in the group with *Macaranga noblei* Elm. and *M. piperi* Merr. but is at once distinguishable from both by its leaves being glabrous on the lower surface. It is less closely allied to *M. amplifolia* Merr., from which it is easily distinguished by its cordate leaves, its shorter inflorescences, and its entirely glabrous leaves and petioles.

MEGISTOSTIGMA Hooker f.

MEGISTOSTIGMA CORDATUM sp. nov.

Herbacea, scandens, partibus junioribus inflorescentiisque exceptis glabra; foliis ovatis, chartaceis, profunde cordatis, acuminatis, longe petiolatis; inflorescentiis racemosis, axillaribus, pedunculatis, usque ad 16 cm longis, floribus inferioribus ♀, superioribus ♂, sepalis ♀ lanceolatis, acuminatis, 6 mm longis.

A scandent, apparently herbaceous vine, nearly glabrous except the inflorescences and very young vegetative parts. Leaves ovate, chartaceous, 8 to 14 cm long, 6 to 9 cm wide, entire, base prominently cordate, apex acuminate, shining when dry, the upper surface olivaceous, the lower paler; lateral nerves above the basal pair 3 or 4 on each side of the midrib, distinct; petioles 3 to 5 cm long. Inflorescences racemose, axillary, solitary, long-peduncled, up to 16 cm in length, the flower-bearing portion 3 to 5 cm long, the lower flowers in each raceme pistillate, the upper ones staminate. Staminate flowers about 6 mm in diameter, their pedicels about 6 mm long, sparingly pubescent, the calyx-lobes 3, orbicular-ovate, obtuse to acute, 3 to 4 mm in diameter; bracteoles lanceolate, acuminate, somewhat pubescent, 4 to 5 mm long, usually hastate-lobed at the base. Pistillate flowers in the lower part of the same raceme as the staminate ones and fewer in number, yellowish-green. Sepals lanceolate, acuminate, about 6 mm long, pubescent on both surfaces, somewhat inflated at the base. Ovary subglobose, somewhat 3-lobed, pubescent, 3-celled; style pubescent, 2 to 3 mm long; stigma subglobose, obscurely 3-lobed, glabrous, fleshy, about 6 mm in diameter.

SAMAR, Mount Canislagan, *Bur. Sci. 17591 Ramos,* April 3, 1914, in dry forests.

The genus *Megistostigma* has previously been known from the Malay Peninsula where it is represented by a single species, *M. malaccense* Hook. f., the type of the genus. The present species differs radically from *M. malaccense* in its ovate, cordate, long-petioled leaves and in its very much larger flowers, the staminate and pistillate ones being borne in the same racemes, not in separate racemes as in Hooker's species. In essential floral characters, by which the genus is distinguished, both the staminate and pistillate flowers conform entirely to those of *Megistostigma.*

PLUKENETIA Linnaeus

PLUKENETIA CORNICULATA Smith in Nov. Act. Soc. Sci. Upsal. 6 (1799) 4.

LUZON, Rizal Province, Barrio of Pulong, *Bur. Sci. 24086 Ramos,* November 25, 1915, in dry places, old clearings.

The genus is new to the Philippines. While the specimen cited above differs in some details from Smith's species, as described, I can detect no differences, in the absence of named material for purposes of comparison, that would warrant me in distinguishing the Philippine form as specifically or varietally distinct. According to Hooker the species extends from the Himalayan region to Java; it extends at least as far to the southeast as Amboina, as it was figured by Rumphius, Herb. Amb. 1 (1741) 194, *t. 79, f. 2,* as *Sajor volubilis.*

TRAGIA Linnaeus

TRAGIA LUZONIENSIS sp. nov.

Scandens, ramulis plus minusve pubescentibus; foliis oblongis, chartaceis, usque ad 9 cm longis, acuminatis, basi leviter cordatis et minute peltatis, margine irregulariter undulatis, nervis utrinque 6 vel 7, patulis, distinctis, anastomosantibus; inflorescentiis ♂ axillaribus, spicatis, tenuibus, 5 ad 7 cm longis, puberulis, solitariis vel fasciculatis; floribus 2 mm diametro, 4-meris, sepalis oblongis, acuminatis, 1 mm longis; staminibus 4, quam sepalis brevioribus; bracteolis anguste oblongis, 0.5 mm longis.

A slender vine, the branches terete, 1 to 1.5 mm in diameter, brownish when dry, the younger ones more or less pubescent, the older ones glabrous. Leaves chartaceous, subolivaceous when dry, shining, oblong, 6 to 9 cm long, 2.5 to 3 cm wide, somewhat narrowed to the rounded, slightly cordate, and minutely peltate base, the apex acuminate, margins irregularly undulate, the upper surface glabrous, the lower surface with rather numerous short, stiff stinging hairs from bulbous bases 1 mm long or less; petioles 5 to 10 mm long, sparingly hirsute, ultimately glabrous; lateral nerves 6 or 7 on each side of the midrib, distinct, spreading, anastomosing, the reticulations lax. Staminate inflorescences spicate, slender, axillary, solitary or fascicled, puberulent, 5 to 7 cm long, the bracteoles narrowly oblong, 0.5 mm long, usually curved and persisting after the flowers fall. Flowers sessile, 2 mm in diameter, 4-merous. Sepals oblong, acuminate, 1 mm long. Stamens 4, rarely 3, shorter than the sepals; rudimentary ovary none. Pistillate flowers and fruits unknown.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 32854 Ramos*, July 26, 1918, in dry forests at low altitudes.

This species is entirely different from the other two known from the Philippines and probably belongs in the alliance with *Tragia involucrata* Linn. It is well characterized by its oblong, somewhat undulate leaves, which are rounded, slightly cordate, and minutely peltate at the base, and by its spicately arranged staminate flowers. In this genus the pistillate flowers are usually found at the base of the staminate inflorescences; but none of the specimens of *Tragia luzoniensis* shows any indication whatever of pistillate flowers, so that apparently the present species is dioecious. The stinging hairs of the present species are very short and are apparently confined to the lower surface of the leaves.

TRAGIA PHILIPPINENSIS sp. nov.

Scandens, ramulis, foliis et fructibus pilis numerosis urentibus instructis; foliis oblongo-ovatis ad oblongo-lanceolatis, usque ad 10 cm longis, basi late truncato-subcordatis, leviter hastatis, sursum gradatim angustatis, tenuiter acute acuminatis; sepalis ♀ 3, accrescentibus, subcoriaceis, ovatis, circiter 10 mm longis, obtusis ad leviter acuminatis, integris; coccis circiter 7 mm diametro, perspicue hispidis, pilis urentibus.

A scandent, herbaceous or subherbaceous vine, the branchlets, leaves, and other parts prominently hispid with scattered, white, stiff, stinging hairs 2 to 3 mm in length. Leaves membranaceous, oblong-ovate to oblong-lanceolate, 7 to 10 cm long, 2.5 to 4 cm wide at the truncate-subcordate and slightly hastate base, gradually narrowed upward to the slenderly and sharply acuminate apex, often with 2 or 3 coarse teeth or shallow lobes on each side near the base, otherwise entire, both surfaces with scattered, stiff, stinging hairs, the upper surface brown or castaneous when dry, the lower greenish; lateral nerves 4 or 5 on each side of the midrib, prominent, anastomosing; petioles about 3 cm long. Staminate flowers 3-merous, the buds triangular, the sepals reniform-ovate, about 3 mm long and 4 mm wide. Disk much thickened; stamens 3, about 2 mm long. Pistillate sepals in fruit 3, subcoriaceous, spreading, entire, ovate, obtuse to somewhat acuminate, about 10 mm long and 7 mm wide. Fruits depressed, about 12 mm in diameter, brown, the cocci globose, about 7 mm in diameter, prominently hispid with white, stiff, spreading, stinging hairs.

LUZON, Abra Province, Mount Posuey, *Bur. Sci. 27013 Ramos*, February 4, 1917, on damp forested slopes.

The third species to be found in the Philippines, and one readily distinguished from *Tragia irritans* Merr. in its leaves being truncate-cordate and somewhat hastate, the sinus very broad and shallow, and the basal lobes not rounded; its three, accrescent, pistillate sepals; and its numerous, very prominent, stinging hairs. It differs notably from the polymorphous *Tragia involucrata* Linn. in its three entire sepals.

TRIGONOSTEMON Blume

TRIGONOSTEMON MACGREGORII sp. nov. § *Pycnanthera*.

Frutex circiter 2 m altus, ramulis inflorescentiisque plus minusve adpresse hirsutis; foliis membranaceis, oblongis, perspicue acuminatis, integris, usque ad 14 cm longis, basi rotundatis vel obtusis, 3-nerviis; paniculis axillaribus, pedunculis, foliis subaequantibus; floribus ♂ circiter 9 mm diametro, sepalis apice perspicue glandulosis, antheris 3, ellipsoideis, integris, ♀ sepalis perspicue ciliato-hirsutis; ovario glabro, stylis 3, brevibus, integris.

A shrub about 2 m high, the branchlets and inflorescences more or less appressed-hirsute. Leaves membranaceous, oblong, prominently acuminate, entire, 10 to 14 cm long, 3 to 5 cm wide, base rounded to obtuse, distinctly 3-nerved; lateral nerves above the basal pair 5 or 6 on each side of the midrib, the midrib and nerves on both surfaces very sparingly appressed-hirsute. Panicles axillary, lax, peduncled, 9 to 16 cm long, the branches slender, irregularly arranged, the lower ones up to 7 cm long. Pistillate and staminate flowers pale-yellow, in the same inflorescences or sometimes in separate inflorescences on the same plant. Staminate flowers about 9 mm in diameter, their pedicels slender, 5 to 10 mm long. Sepals 5, elliptic to elliptic-ovate, 1.5 to 2 mm long, glabrous or with very few ciliate-hirsute hairs, glandular-punctate, the apex obtuse or notched and with a large conspicuous gland. Petals membranaceous, glabrous, obovate, about 4.5 mm long, 3 mm wide, the apex somewhat obliquely truncate-rounded. Disk 1 mm in diameter, entire. Androphore about 2 mm long, anthers 3, ellipsoid, entire, 0.4 mm long, the filaments 0.5 mm long. Pistillate flowers similar to the staminate ones, differing in their larger, prominently hirsute-ciliate sepals which are oblong and about 3 mm long. Ovary ovoid, glabrous; styles 3, entire, 0.5 mm long. Capsules subglobose, about 1 cm long. Seeds about 6 mm in diameter.

PANAY, Antique Province, Culasi, *Bur. Sci. 32424 McGregor* (type), June 3, 1918, in forests, altitude about 300 meters. The same species is represented by *Bur. Sci. 26228 McGregor* from the vicinity of Paete, Laguna Province, Luzon, June, 1915.

This species is not closely allied to any other known Philippine form and differs from the other species of this section in its axillary inflorescences. It is easily recognized by its lax inflorescences and its distinctly 3-nerved leaves, the basal nerves usually extending to near the middle of the leaf.

TRIGONOSTEMON LAXIFLORUS sp. nov.

Frutex, partibus junioribus et subtus foliis plus minusve pubescentibus; foliis oblongis ad oblongo-lanceolatis, circiter 25 cm longis, perspicue acuminatis, basi acutis, nervis utrinque circiter 18; inflorescentiis ♀ tenuibus, laxis, axillaribus, usque ad 30 cm longis; floribus paucis, longissime pedicellatis; bracteis foliaceis, lanceolatis, 1 ad 1.5 cm longis; sepalis oblongis ad oblongo-ovatis, acuminatis, ut videtur accrescentibus, 7 ad 11 mm longis; ovario ovoideo, pubescente; stylis 3, brevibus, partitis.

A shrub, more or less pubescent. Branches terete, glabrous, about 4 mm in diameter, the younger parts somewhat pubescent. Leaves oblong to oblong-lanceolate, about 25 cm long and 7 cm wide, narrowed below to the acute base and above to the conspicuously acuminate apex, the margins obscurely and distantly undulate-crenate, the upper surface glabrous, dark-olivaceous when dry, the lower surface paler, rather softly pubescent on the midrib, nerves, and reticulations, and with similar but more scattered hairs on the epidermis; lateral nerves about 18 on each side of the midrib, prominent; petioles 3 to 4.5 cm long, pubescent when young, soon becoming glabrous. Pistillate inflorescences slender, lax, rather few-flowered, long-peduncled, pubescent, up to 30 cm long, the branches few, rather short, each bearing from 1 to 3 very long-peduncled flowers, the branches subtended by lanceolate, 1 to 1.5 cm long, leaflike bracts. Pedicels 2 to 5 cm long, thickened upward, usually with a small linear-oblong bracteole. Sepals 5, oblong to oblong-ovate, acuminate, sparingly pubescent, apparently somewhat accrescent and persistent, 7 to 11 mm long, 2.5 to 5 mm wide. Disk glabrous, with 5, rounded, orbicular-ovate lobes. Ovary ovoid, rather densely cinereous-pubescent; styles 3, about 1.5 mm long, cleft nearly to the base. Capsules apparently globose, about 1 cm in diameter.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 31097 Ramos & Edaño,* May 16, 1918, in damp forests.

This species is well characterized by its very slender, few-flowered, elongated, bracteate inflorescences and by its apparently accrescent, persistent, rather large sepals. It is closely allied to *Trigonostemon acuminatus* Merr., from which it is easily distinguished by its smaller bracts, and by its leaves being softly pubescent beneath.

TRIGONOSTEMON LUZONIENSE sp. nov.

Frutex erectus, perspicue hirsutus vel villosus, ramulis circiter 5 mm diametro, cicatricibus magnis instructis; foliis subcoriaceis, oblongo-obovatis ad oblanceolatis, 15 ad 23 cm longis, acutis vel obtusis, deorsum angustatis, integris, nervis utrinque circiter 10, perspicuis; infructescentiis longe pedunculatis, hirsutis, axillaribus, racemosis vel depauperato-paniculatis, foliis subaequantibus; capsulis circiter 1 cm diametro, dense hirsutis.

A shrub about 1 m high, the branchlets, petioles, inflorescences, and leaves on the lower surface more or less hirsute or villous. Ultimate branches about 5 mm in diameter, more or less pubescent, and with large petiolar scars. Leaves chartaceous or subcoriaceous, narrowly oblong-obovate to oblanceolate, 15 to 23 cm long, 6 to 8 cm wide, rather pale when dry, the apex acute to obtuse, narrowed below to the acute or very abruptly obtuse base, the margins entire, the upper surface glabrous, the lower conspicuously pubescent on the midrib, nerves, and reticulations; lateral nerves about 10 on each side of the midrib, curved-ascending, distinct, the reticulations lax; petioles 1.5 to 2 cm long, densely hirsute. Infructescences axillary, equaling or somewhat longer than the leaves, very long-peduncled, hirsute, racemose or depauperate-paniculate, flower-bearing in the upper 10 cm, the branchlets or pedicels subtended by bracts or very greatly reduced leaves which may reach a length of 1.5 cm, the fruiting pedicels up to 3 cm long, thickened upward. Capsules depressed-globose, densely hirsute, about 1 cm in diameter, composed of 3 dehiscent cocci.

LUZON, Camarines Province, Paracale, *Bur. Sci. 33539 Ramos & Edaño,* November 28, 1918, in forests along small streams at low altitudes.

This species differs from *Trigonostemon hirsutus* C. B. Rob. in its smaller, fewer-nerved leaves, and from *T. merrillii* Elm.

in its leaves being entirely glabrous on the upper surface; it seems to be more closely allied to the latter.

TRIGONOSTEMON ANOMALUS sp. nov.

Frutex circiter 8 m altus, inflorescentiis parcissime hirsutis exceptis glaber; foliis submembranaceis, oblongo-ovatis, usque ad 18 cm longis, longe acuminatis, integris, nervis utrinque circiter 7; inflorescentiis axillaribus, paucifloris, 1 ad 2 cm longis, racemosis vel corymbosis; floribus ♂ magis numerosis, sepalis 5, ellipticis, circiter 3 mm longis, integris, petalis bifidis, quam sepalis brevioribus latioribusque, glabris; floribus ♀ paucis, longe pedicellatis, sepalis 5 mm longis, petalis nullis.

A shrub about 8 m high, entirely glabrous except for the very slightly hirsute inflorescence. Branches slender, terete, reddish brown. Leaves alternate, oblong-ovate, membranaceous, 7 to 18 cm long, 3.5 to 6.5 cm wide, pale or somewhat olivaceous when dry, somewhat shining, entire, base acute, apex long and slenderly acuminate; lateral nerves about 7 on each side of the midrib, slender, distant, curved, the reticulations lax, subobsolete; petioles 2 to 7 mm long. Inflorescence axillary, 1 to 2 cm long, few-flowered, racemose or cymose. Female flowers apparently 1, few, or perhaps none in some inflorescences, their pedicels about 1.5 cm long, thickened upward. Sepals 5, imbricate, glabrous, oblong-elliptic, obtuse, 5 mm long, 3 mm wide. Petals none (or fallen). Ovary ovoid, glabrous, about 2 mm in diameter, 3-celled, cells 1-ovuled; styles 3, about 1 mm long, recurved. Male flowers more numerous than the females, their pedicels 5 to 6 mm long, the buds globose. Sepals of nearly mature buds 5, eglandular, imbricate, elliptic, rounded, concave, about 3 mm long, 2.2 mm wide, glabrous or externally with very few, scattered hairs. Petals 5, imbricate, 2 to 2.5 mm long, 3 to 3.5 mm wide, cleft to about the middle by a broad sinus, the lobes rounded. Stamens 3; anthers sessile, entire, 2-celled, about 1 mm long, longitudinally dehiscent.

MINDANAO, Zamboanga District, Naganaga, *For. Bur. 22018 Villamil,* June 2, 1914, on ridges, altitude about 75 meters, the flowers red.

The species is placed in *Trigonostemon* although it is anomalous in that its pistillate flowers apparently have no petals; as I had for examination but a single pistillate flower, however, it is possible that the petals had already fallen. Otherwise the species is distinguished by its short, racemose or corymbose inflorescences. It may belong in the section *Tylosepalum*.

CODIAEUM Jussieu

CODIAEUM TRICHOCALYX sp. nov.

Frutex erectus, dioicus, partibus junioribus inflorescentiisque exceptis glaber; foliis plus minusve confertis, chartaceis, olivaceis, oblongo-obovatis ad late oblanceolatis, usque ad 20 cm longis, obtusis vel breviter latissime obtuse acuminatis, basi cuneatis, integris, nervis utrinque circiter 15, patulis; petiolo 1.5 ad 2.5 cm longo; racemis ♂ elongatis, adpresse pubescentibus; floribus fasciculatis, pedicellis sepalisque dense longe ciliato-hirsutis; petalis minutis, glabris, oblongo-spatulatis, 1.5 mm longis; staminibus circiter 100.

An erect, apparently unbranched, dioecious shrub, glabrous except the younger parts and the inflorescences. Branches terete, smooth, the ultimate ones 3 to 4 mm in diameter. Leaves crowded at the apices of the branches, chartaceous, oblong-obovate to broadly oblanceolate, 13 to 20 cm long, 4.5 to 7 cm wide, apex obtuse to broadly and obtusely acuminate, gradually narrowed in the lower two-thirds to the cuneate base; lateral nerves about 15 on each side of the midrib, slender, spreading, very obscurely anastomosing; petioles 1.5 to 2.5 cm long. Staminate inflorescences elongated, 20 to 40 cm in length, appressed-pubescent with short hairs. Flowers white, in distant fascicles, up to 5 at a node, but 1 or 2 opening at one time, their pedicels and the sepals densely covered with long, rather stiff, spreading, white or pale hairs, the pedicels up to 1 cm in length. Sepals obovate, rounded, about 4 mm long. Petals minute, oblong-spatulate, 1.5 mm long, glabrous, entire. Disk-glands about 10, thick, angled, about 0.8 mm long, truncate. Stamens 100 or more, the filaments glabrous, 3 to 4 mm long.

LUZON, Zambales Province, Mount Aglao, *Bur. Sci. 26797 Edaño,* December 5, 1916, in forests at low altitudes.

A species manifestly allied to *Codiaeum luzonicum* Merr., and *C. cuneifolium* Pax & K. Hoffm., from both of which it is at once distinguished by the dense indumentum on the pedicels and calyces, which consists of long, stiff, spreading, white or pale hairs that are 0.8 to 1 mm in length.

CODIAEUM MEGALANTHUM sp. nov.

Frutex 1 m altus, haud ramosus, floribus ♀ exceptis glaber; foliis longe petiolatis, chartaceis, oblongo-oblanceolatis, 12 ad 27 cm longis, apice rotundatis vel latissime et brevissime acuminatis; inflorescentiis ♂ racemosis, usque ad 35 cm longis, floribus 1.2 ad 1.5 cm diametro, tenuiter longe pedicellatis, plerumque solitariis, sepalis glabris, staminibus circiter 100, glandulis circiter 15, quadratis, denticulatis; floribus ♀ pubescentibus, stylis 3, recurvatis, integris.

An erect, normally unbranched shrub, about 1 m high, entirely glabrous except the pistillate flowers. Leaves chartaceous, oblong-oblanceolate, 12 to 27 cm long, 3 to 7 cm wide, entire, olivaceous when dry, the apex rounded, or sometimes very broadly and shortly acuminate, gradually narrowed below to the cuneate or acute base; lateral nerves spreading, slender, distinct, up to 20 on each side of the midrib, anastomosing, the reticulations very lax, indistinct; petioles 3.5 to 7 cm long. Pistillate and staminate inflorescences either on the same plant or on separate plants, elongated, 17 to 35 cm long, rachis glabrous. Staminate flowers up to 1.5 cm in diameter, white, their pedicels slender, 2 to 2.5 cm long, solitary or somewhat fascicled. Sepals glabrous, orbicular, about 6 mm in diameter. Stamens 100 or more, their filaments about 6 mm long. Disk glands about 15, stout, 4-angled, about 1.2 mm long, the more or less quadrate apex minutely toothed. Petals none. Pistillate flowers racemose, solitary, their pedicels 1.2 mm long or less. Sepals somewhat pubescent, broadly ovate, acuminate, 1.5 mm long. Ovary ovoid, cinereous-pubescent; styles 3, entire, recurved, 6 mm long.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 27353 Ramos* (type), March 12, 1917, in forests at low altitudes; between Bangui and Claveria, *Bur. Sci. 33014 Ramos,* August 1, 1918: Cagayan Province, near Mount Narig, *For. Bur. 19640 Curran,* January 25, 1912.

The type was originally identified as *Codiaeum cuneifolium* Pax & K. Hoffmann, the latter species being identical with *C. luzonicum* Merr. It is distinguished from *C. luzonicum* and from *C. palawanense* Elm. by its larger staminate flowers; in being entirely glabrous except for its pistillate flowers; and more especially in its undivided style arms. In both *Codiaeum luzonicum* (including *C. cuneifolium*) and *C. palawanense* the styles are divided to the base, forming six equal arms. In the present species as in others of this group the staminate flowers are apetalous.

CODIAEUM CILIATUM sp. nov.

Frutex monoicus, 1 ad 2 m altus, perspicue ciliato-hirsutus; foliis oblongo-ovatis ad late oblongo-oblanceolatis, membranaceis ad chartaceis, utrinque plus minusve longe albido-ciliatis, usque ad 35 cm longis, acutis ad acuminatis, basi cuneatis, nervis utrinque 10 ad 20; inflorescentiis 30 ad 60 cm longis, multifloris; floribus ♂ extus glabris vel subglabris, 5-meris, plerumque fasciculatis, staminibus circiter 45; floribus ♀ pubescentibus, ovario pubescente atque ciliato-hirsuto; stylis 3, bipartitis.

An erect, unbranched, monoecious shrub, 1 to 2 m high, ciliate-hirsute with scattered, spreading, stiff, white hairs, especially on the inflorescences and lower surface of the leaves. Leaves oblong-obovate to broadly oblong-oblanceolate, membranaceous to chartaceous, 25 to 35 cm long, 9 to 15 cm wide, olivaceous when dry, the lower surface somewhat paler than the upper, the apex acute to somewhat acuminate, narrowed in the lower two-thirds to the usually cuneate base; lateral nerves 10 to 20 on each side of the midrib, prominent, spreading, anastomosing, the reticulations lax; petioles 4 to 8 cm long. Pistillate and staminate inflorescences on the same plant, racemose, stout, 30 to 60 cm long, the rachis cinereous-pubescent with short, appressed hairs and ciliate-hirsute with long, stiff, spreading ones. Staminate flowers usually numerous, fascicled, from 2 or 3 to as many as 100 in a fascicle, their pedicels up to 1 cm in length. Sepals orbicular to reniform, glabrous, the inner three about 4 mm in diameter, the outer two usually smaller. Petals not seen, if present then very minute. Stamens about 45. Pistillate flowers solitary, racemosely arranged, their pedicels 1 to 3 mm long, calyx pubescent and ciliate-hirsute; styles 3, each cleft nearly to the base into two 6-mm long arms. Capsules about 1 cm in diameter, brownish, shining, with few, scattered, short hairs, their pedicels 5 to 10 mm long.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 31233* (type), *31230, 31231, 31232 Ramos & Edaño,* April 6, 1918, in forests along small streams, with the Visayan names *calangcang* and *panagang.*

This species belongs in the same group as *Codiaeum luzonicum* Merr., from which I do not consider *C. cuneifolium* Pax & Hoffm. to be specifically distinct. *Codiaeum ciliatum* is closely allied to *C. hirsutum* Merr., from which it is distinguished by its much broader leaves, its shorter inflorescences, and the glabrous or nearly glabrous sepals of the staminate flowers.

Pax and Hoffmann separated *Codiaeum cuneifolium* from *C. luzonicum* on the basis that the former has monoecious flowers and pubescent capsules, and that the latter is dioecious with glabrous capsules. As a matter of fact the capsules are appressed-pubescent in both species; the plants are more often monoecious but are frequently dioecious. There are no floral or vegetative characters by which they may be distinguished. In this connection it is well to call attention to the fact that the drawing of the pistillate flower given by Pax and Hoffmann [6] is erroneous in that the styles are shown as very short, obovate, and 3-toothed. In this species, as in *C. luzonicum* and all of the other indigenous ones of the genus found in the Philippines, the three styles are elongated and cleft nearly to the base into two long arms. In this character all of our indigenous species of the genus differ from typical *Codiaeum*, and a more natural arrangement would be their segregation as a subgenus or perhaps even their separation generically from *Codiaeum*.

CODIAEUM MACGREGORII sp. nov.

Frutex vel arbor parva, ramulis inflorescentiisque exceptis glabra; foliis lineari-oblongis, usque ad 30 cm longis, 3 ad 3.5 cm latis; inflorescentiis ♀ usque ad 45 cm longis, cinereo-pubescentibus; floribus 5-meris, sepalis dense pubescentibus; ovario dense hirsuto; stylis 3, bifidis, elongatis; capsulis dense hirsutis, obovoideis.

A shrub or small tree, the young branchlets and inflorescences densely cinereous-pubescent with short subappressed hairs. Leaves glabrous, chartaceous, linear-oblong, 30 to 40 cm long, 3 to 3.5 cm wide, their margins parallel, the base rather abruptly acute or cuneate, the apex acuminate; lateral nerves 20 to 30 on each side of the midrib, spreading, anastomosing, distinct; petioles 5 to 8 cm long. Pistillate inflorescences up to 45 cm in length, solitary, subtended by an oblong, sessile leaf about 10 cm long and 3 cm wide. Flowers rather numerous, racemosely arranged, their pedicels 2 to 5 mm long. Sepals densely pubescent, oblong-ovate, acute, about 2 mm long. Ovary very densely hirsute; styles 3, glabrous, each cleft nearly to the base into two 5-mm long arms. Young capsules obovate, about 7 mm long, rather densely hirsute with pale, stiff, spreading hairs.

PANAY, Antique Province, Culasi, *Bur. Sci. 32419 McGregor*, May 24, 1918, on forested slopes, altitude about 900 meters.

This species is well characterized by its elongated, narrow, glabrous leaves and its rather densely pubescent inflorescences and hirsute capsules; the indumentum is entirely different from that of *C. ciliatum*.

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[6] Engl. Pflanzenreich 47 (1911) 29, *f. 7 D.*

OMPHALEA Linnaeus

OMPHALEA GRANDIFOLIA sp. nov.

Frutex erectus, haud ramosus, circiter 3 m altus, inflorescentiis parce pubescentibus exceptis glaber; foliis coriaceis, longissime petiolatis, oblongis, 50 ad 60 cm longis, apice breviter acuminatis; nervis utrinque 14 ad 18, perspicuis; inflorescentiis lateralibus, diffusis, multiramosis, usque ad 80 cm longis, ramis irregulariter dispositis, elongatis; floribus ♀ fasciculatis, pedicellatis, circiter 2 mm longis; fructibus junioribus subglobosis, circiter 3 cm diametro.

An erect unbranched shrub, about 3 m high, the trunk 4 to 8 cm in diameter, glabrous except the somewhat puberulent inflorescences. Leaves coriaceous, shining, oblong, 50 to 60 cm long, 15 to 20 cm wide, the apex shortly acuminate, base acute or obtuse and with two conspicuous glands on the upper surface at the junction with the petiole; lateral nerves 14 to 18 on each side of the midrib, prominent as are the reticulations; petioles 14 to 28 cm long. Inflorescences lateral, much branched, diffuse, rather rigid, up to 80 cm in length. The primary branches irregularly arranged. Pistillate flowers numerous, fascicled, each fascicle usually subtended by a conspicuous gland. Pedicels about 8 mm long. Sepals 5, obtuse, oblong-elliptic to elliptic-ovate, about 2 mm long, membranaceous, slenderly nerved, their margins slightly ciliate. Ovary ovoid, glabrous, 3-celled. Immature fruit subglobose, about 3 cm in diameter, 3-celled, each cell with a single large seed.

PANAY, Capiz Province, Mount Macosolon and Jamindan, *Bur. Sci. 30813* (type), *30825 Ramos & Edaño,* April 23, and May 25, 1918, in damp forests along small streams.

This species is strongly characterized by its very large, long-petioled leaves as well as by its habit, it being described by the collectors as strictly erect and unbranched; the pistillate inflorescences are unusually large.

OMPHALEA SARGENTII sp. nov.

Frutex scandens, glaber; foliis oblongis, subcoriaceis, in siccitate pallidis, nitidis, utrinque concoloribus, circiter 20 cm longis, basi rotundatis ad obtusis, utrinque glandulis solitariis perspicuis instructis, apice obtusis ad brevissime acuminatis vel acutis, nervis utrinque circiter 8, perspicuis; fructibus globosis, circiter 5 cm diametro.

A scandent glabrous shrub reaching a length of 20 cm and a diameter of 4 cm, the branches terete, longitudinally striate when dry, pale; leaves subcoriaceous, pale and shining when dry, oblong, about 20 cm long, 8 to 9 cm wide, base rounded to obtuse, with a prominent gland on each side at the juncture of the lamina with the petiole, the apex obtuse or very shortly acute or acuminate; lateral nerves about 8 on each side of the midrib, prominent on the lower surface, distant, anastomosing, the reticulations lax; petioles stout, about 3.5 cm long; infructescences up to 40 cm in length, the branches few, short, spreading. Fruits globose, about 5 cm in diameter, smooth, glabrous, dark-brown when dry, shining, the seeds about 3 cm long and wide.

BANCALAN, between Palawan and Balabac, *C. M. Weber*, September 2, 1916, in forests, altitude about 3 meters.

A species well characterized by its few-nerved leaves and large fruits, by which it is readily distinguished from *Omphalea philippinensis* Merr. and *O. malayana* Merr.; the fourth species for the Philippine-Malayan region. It is dedicated to Dr. C. S. Sargent, director of the Arnold Arboretum, under whose auspices Weber's collection was made.

EXCOECARIA Linnaeus

EXCOECARIA PACHYPHYLLA sp. nov. § *Commia.*

Frutex circiter 2 m altus, glaber, ramis ramulisque teretibus; foliis oppositis, coriaceis, oblongis ad oblongo-ovatis, integris, usque ad 10 cm longis, apice breviter et late obtuse acuminatis, basi acutis, nervis utrinque circiter 9, patulis, vix perspicuis; racemis ♂ terminalibus, circiter 2 cm longis, bracteolis unifloris, floribus distincte pedicellatis, sepalis ovatis, margine glanduloso-denticulatis.

A glabrous shrub about 2 m high, the branches and branchlets terete, usually reddish-brown. Leaves opposite, thickly coriaceous, oblong to oblong-obovate, 7 to 10 cm long, 2.5 to 3.5 cm wide, smooth, shining, the upper surface pale-olivaceous, the lower paler when dry, entire, base acute, apex with a short, very broad, blunt acumen; lateral nerves about 9 on each side of the midrib, not prominent, spreading, rather obscurely anastomosing, usually more distinct on the upper than on the lower surface; petioles 1 to 1.5 cm long. Staminate racemes terminal, simple, solitary, about 2 cm long, the bracteoles ovate, rounded, about 1 mm long, the margins obscurely glandular-denticulate, 1-flowered, the glands prominent, about 1 mm in diameter. Pedicels stout, about 1 mm long. Sepals suborbicular, about 0.8

mm in diameter, margins obscurely glandular-denticulate. Filaments nearly 1 mm long. Pistillate flowers and fruits not seen.

LUZON, Tayabas Province, Mount Cadig, *Bur. Sci. 25404 Yates*, December 12, 1916, in the mossy forest, altitude at least 800 meters.

A characteristic species, readily distinguished by its thick, entire, opposite leaves, and its short, simple, terminal or subterminal racemose, not spicate, staminate inflorescences. Under Pax and Hoffmann's arrangement of the species of *Excoecaria*, it comes nearest to *Excoecaria crenulata* Wight and *E. bantamensis* Muell.-Arg.

EXCOECARIA MIRANDAE sp. nov. § *Commia*.

Frutex monoicus, circiter 2 m altus, glaber; foliis oppositis, chartaceis, oblongis, usque ad 13 cm longis, olivaceis, integris, acuminatis, basi acutis ad subobtusis, nervis utrinque circiter 9, curvatis, anastomosantibus, reticulis subobsoletis; inflorescentiis junioribus terminalibus, circiter 4 cm longis, basi floribus ♀ solitariis instructis; bracteolis unifloris; floribus ♂ sepalis lanceolatis, 1.5 mm longis, acuminatis, ♀ ovatis, 2.2 mm longis, longe et tenuiter acuminatis.

A monoecious glabrous shrub about 2 m high, the branches and branchlets slender, terete, reddish-brown. Leaves opposite, chartaceous, olivaceous when dry, the lower surface paler than the upper, 10 to 13 cm long, 3.5 to 4 cm wide, entire, base acute, apex distinctly acuminate, the acumen rather blunt; lateral nerves about 9 on each side of the midrib, curved, rather distinct, anastomosing, the reticulations obsolete or subobsolete; petioles 5 to 8 mm long. Inflorescences terminal, when young about 4 cm long, with a single pistillate flower at the base, the bracteoles 1-flowered. Pistillate flowers: Sepals ovate, 2.2 mm long, long and slenderly acuminate, the shoulders minutely denticulate. Ovary ovoid, glabrous, the style-arms rather stout, about 2 mm long. Staminate flowers: Sepals lanceolate, long-acuminate, about 1.3 mm long, the bracts ovate, acuminate. Fruits apparently about 1.5 cm in diameter, the pericarp crustaceous.

BASILAN, Bocboc Barrio, near Matangal Point, *For. Bur. 20062 Miranda*, October 4, 1912, altitude about 25 meters.

The alliance of this species is manifestly with *Excoecaria bicolor* Hassk., from which it is distinguished by being monoecious, although Hasskarl states that *E. bicolor* is sometimes monoecious; by its longer inflorescences; and by its prominently long-acuminate pistillate sepals.

EXCOECARIA MACROPHYLLA (Hassk.) J. J. Sm. in Meded. Dept. Landbouw 10 (1910) 611.

LUZON, Nueva Ecija Province, Muñoz, *For. Bur. 6029 Zschokke*, November, 1906; Pangasinan Province, Umingan, *For. Bur. 26299 Ablaza*, September, 1916, in both localities known as *sausao* or *sausau*.

This species has previously been reported only from Java and from Borneo, but I can detect no characters by which the Luzon form can be distinguished from the Javan one, of which three specimens collected by Koorders are before me. The Philippine form has intensely irritating milky juice, Ablaza merely stating that it burns the skin, while Zschokke states: "The sap is milky and the natives dread it very much. It makes painful burns, destroying the skin as an acid does."

SAPIUM Jacquin

SAPIUM LUZONICUM (Vidal) comb. nov.

Myrica luzonica Vidal Sinopsis Atlas (1883) 40, *t. 90, f. B;* Rolfe in Journ. Linn. Soc. Bot. 21 (1884) 316.

Sapium merrillianum Pax & Hoffm. in Engl. Pflanzenreich 52 (1912) 213.

Sapium lateriflorum Merr. in Philip. Journ. Sci. 1 (1906) Suppl. 83; Elm. Leafl. Philip. Bot. 4 (1911) 1303, non Hemsl. (1901).

Urandra elliptica Merr. in Philip. Journ. Sci. 5 (1910) Bot. 195.

The type of *Myrica luzonicum* Vidal was from Montalban, Rizal Province, Luzon, a specimen with staminate flowers; and, while the original description is short, both it and its accompanying figure definitely place the species as identical with the one I later described as *Sapium lateriflorum*, this being later renamed by Pax and Hoffmann *Sapium merrillianum*. The type of *Sapium lateriflorum* Merr. was from Bataan Province, Luzon. The form later described by me as *Urandra elliptica*, the type being a fruiting specimen, was also from Bataan Province; it is clearly synonymous with *Sapium luzonicum*, representing a plant with relatively broader leaves than the common form. The species is now represented by the following specimens:

LUZON, Ilocos Sur Province, Tambor, *For. Bur. 13027 Paraiso;* Danglao, *For. Bur. 23109 Cruz:* Bulacan Province, Angat, *Merrill Phil. Pl. 1407:* Bataan Province, Mount Mariveles, Lamao, *Williams 643, For. Bur. 338 Barnes, For. Bur. 2565 Borden* (type of *Sapium lateriflorum* Merr. and of *S. merrillianum* Pax), *For. Bur. 17601, 19153 Curran;* Duale, *For. Bur. 20003 Topacio* (type of *Urandra elliptica* Merr.): Rizal Province, San Isidro, *For.*

Bur. 1991 Ahern's collector, Merrill Phil. Pl. 2013: Laguna Province, Mount Maquiling, Los Baños, *For. Bur. 11676, 19808 Whitford, For. Bur. 11919 Tamesis, For. Bur. 22955 Calycosa, For. Bur. 13232 Curran.* MINDORO, *For. Bur. 9913 Merritt.* PALAWAN, Brooks Point, *Elmer 12630.* TICAO, *For. Bur. 1080 Clark.* BUCAS GRANDE, *Bur. Sci. 35078 Ramos & Pascasio.* MINDANAO, Davao Province, *For. Bur. 27587 De Mesa.*

In forested ravines and on forested slopes at low altitudes. Endemic.

EUPHORBIA Linnaeus

EUPHORBIA LUZONIENSIS sp. nov. § *Chamaesycae.*

Herba perennis, tenuibus, prostratis, e radicis lignosis, ramulis parce pubescentibus; foliis orbicularis ad orbiculari-ovatis, subcoriaceis, integris vel obscure crenulatis, apice late rotundatis, basi inaequilateralibus, usque ad 8 mm longis; involucris numerosis 1.5 mm longis cymosis, cymis 1 ad 1.5 cm longis, foliis depauperatis 1 ad 3 mm longis instructis, glandulis reniformibus, integris; capsulis ovoideis, 1.5 mm longis, 3-angulatis, leviter pubescentibus.

A slender, prostrate, dichotomously branched, perennial herb from thick woody roots, the branchlets very slightly pubescent, the woody roots up to 8 mm in diameter. Branches 1 mm in diameter or less, the internodes up to 1.5 cm in length. Leaves orbicular to orbicular-ovate, 5 to 8 mm long, subcoriaceous, entire or very obscurely crenulate, apex broadly rounded, base distinctly inequilateral, more or less oblique on one side, sometimes shallowly laterally cordate, olivaceous when dry, the upper surface glabrous, the lower when young often slightly pubescent, soon becoming glabrous; lateral nerves 3 or 4 on each side of the midrib, faint, obscure, the reticulations close; petioles 1 to 2 mm long; stipules broadly ovate, thin, denticulate, sometimes cleft, 0.5 to 1 mm long. Involucres rather numerous, forming terminal leafy cymes 1 to 1.5 cm long and about as wide, the leaves associated with the involucres in the inflorescence similar to the normal ones but very much smaller, 1 to 3 mm long. Individual involucres cup-shaped, very slightly pubescent, about 1.5 mm long, their pedicels 1 to 1.5 mm long; bracteoles thin, short, somewhat ciliate; glands reniform, about 0.6 mm wide, the appendages entire. Ovary slightly pubescent; styles cleft about one-third to the base, the arms short, somewhat thickened. Capsule ovoid, about 1.5 mm long, very slightly pubescent, 3-angled. Seeds slightly rugose, about 1 mm long.

LUZON, Ilocos Norte Province, between Burgos and Bangui, *Bur. Sci. 27309* bis (type), *27517 Ramos,* March, 1917, on open dry slopes at low altitudes.

This species is distinguished among its congeners such as *Euphorbia humifusa* Willd., *E. makinoi* Hayata, and allied forms by its orbicular leaves and its cymose inflorescences.

EUPHORBIA MAKINOI Hayata in Journ. Coll. Sci. Tokyo 30[1] (1911) 262.

Euphorbia microphylla Hayata op. cit. 20[3] (1904) 79, *t. 5, f. H,* non Heyne.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 27309, 32746 Ramos,* February, 1917, and July, 1918, in open dry places at low altitudes.

This species has previously been known only from Formosa, the specimens cited above agreeing perfectly with Hayata's description and figure. It is very closely allied to *Euphorbia neocaledonica* Boiss., as represented by *Cribs 753* and *758* from New Caledonia, the former number having minutely serrulate leaves, as described by Boissier, the latter having entire leaves.

DETERMINATION OF GLUCOSE AND STARCH BY THE ALKALINE POTASSIUM PERMANGANATE METHOD[1]

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SIX TEXT FIGURES

No one analytical method has been so useful in the analysis of saccharine products as has Fehling's in its numerous modifications, though many attempts had been made to substitute others, entirely different in principle, for the copper-reducing method. Results have shown that the substitutes have not been as satisfactory, and the copper-reducing method has therefore remained in its classical use. In its more recent modifications, it is one of the most accurate and convenient methods we have. At first sight, it might appear a superfluous task to attempt to find a substitute for such a reliable method, but I thought it would be worth while to work out an entirely different, simpler, and more rapid one to save time and material in the numerous analyses of starchy products that the department of chemistry has to perform in connection with the investigation of the feeding values of grains and root crops.

Among the many other possible methods, the alkaline potassium permanganate appeared to me to be the most promising. Previous preliminary experiments have shown that, when glucose was oxidized by alkaline potassium permanganate solution of a definite concentration, the amount oxidized decreased with increase in concentration of the former, if the length of time of heating was the same. The same thing has been observed also by Witzemann and others. I have studied the conditions of the reaction, by using different concentrations of alkali and of potassium permanganate, and by standardizing the time of heating, as was done with the copper-reducing method. From the results obtained a procedure was worked out for the determination of starch in starchy products, and a glucose-starch table, similar to the tables of Munson and Walker and of Allihn, was constructed. These results are given in the following pages.

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[1] This investigation was undertaken at the suggestion of Assistant Professor Manuel L. Roxas and carried out under his personal supervision. The author desires to express his thanks and appreciation to Professor Roxas for his advice and suggestion.

DISSOCIATION OF THE GLUCOSE MOLECULE

According to Mathews,(8) sugars behave as weak acids; that is, the hydrogen of one of the hydroxyl groups dissociates into ion. Cohen (2) has found the dissociation constant of glucose to be 5.9×10^{-13}. It is believed that the dissociating hydrogen is that of the hydroxyl group next to the aldehyde group. Nef,(10) however, believes that the dissociating hydrogen is not always the same. It may be the hydrogen of any of the hydroxyl groups of the glucose molecule.

In the presence of an alkali a glucose salt is formed, and this dissociates into a positive and the negative glucose ion. The latter, being unstable, undergoes a rearrangement resulting in the disturbance of electrical equilibrium and the subsequent formation of easily oxidizable compounds.

ACTION OF THE ALKALI

Mathews's (8) experiments show that, under the action of an alkali, the glucose molecule is broken up into a number of reducing particles. He concludes that, in the rearrangement of the glucose molecule, intramolecular oxidation and reduction take place. These conclusions were derived from his experiments on the rate of formation of acids from sugars by alkalies. According to these experiments, acids are formed secondarily. The first effect of the alkali is to produce easily oxidizable bodies, which in turn become acids—a result perhaps obtained "by intramolecular oxidation or by the reduction of some of the reaction products."

According to Witzemann's(14) views, the alkali serves as a catalyst in facilitating the oxidation of glucose and its decomposition products. These views seem to be confirmed by the works of Nef(10) and his pupils, and by those of Mathews.(8)

THE EFFECT OF ALKALI CONCENTRATION UPON OXIDATION

Glucose and other sugars are easily oxidized in alkaline solutions. It has been found by Mathews and McGuingan(9) that the velocity of oxidation of sugars is much greater in an alkaline than in an acid solution, and the difference in the rate of oxidation of the different sugars studied, observed in the latter solution, disappears in the former. The velocity of oxidation in alkaline solutions of all the common sugars undergoes steady acceleration from the beginning of the reaction and for some time thereafter. When air is the source of oxygen, the optimum concentration of alkali for oxidation is between N and 2 N, the velocity falling off in either direction.

According to investigations made on the oxidation of sugars with alkaline potassium permanganate solution, smaller concentrations of alkali are more effective than those used in the oxidation with air. Witzemann(14) found that the optimum concentration of alkali lies close to 0.1 to 0.2 N, or between these two figures. He also observed that oxidation is markedly induced even by very small concentrations of alkali, 0.014 N alkali giving strong effect.

EARLY INVESTIGATIONS OF THE METHOD OF ANALYSIS

One of the earliest investigations on the oxidation of organic substances by potassium permanganate was performed by Berthelot.(1) He worked principally on the oxidation of fats and found that oxidation is greater in an alkaline than in an acid medium. Donath and Ditz(3) found that, when boiled at a high temperature and with relatively high concentration of potassium permanganate, organic bodies give carbon dioxide and water as oxidation products. Smolka,(13) experimenting on simple sugars, found that, when glucose is completely oxidized, the products of oxidation are carbon dioxide and water; and that, when oxidation is carried on in the cold, small amounts of oxalic acid are detected. Karez(6) performed a series of experiments on the oxidation of carbohydrates, using sugar solutions. The sugars were oxidized by heating the solution for fifteen minutes, with potassium permanganate containing 20 per cent of sulphuric acid, and determining the amount of oxalic acid produced by titration with standard potassium permanganate solution. Hetper(5) found that there is a difference both in the products and in the degree of oxidation, when this is carried on in acid or alkaline media. Donath and Ditz,(3) working on the same subject, came to the conclusion that oxalic acid is a product obtained when sugars are oxidized by potassium permanganate in an alkaline solution, while carbon dioxide and water are obtained in an acid medium. This conclusion agrees with that from Witzemann's results.

A series of oxidation experiments with carbohydrates was conducted by Greifenhagen, König and Scholl,(4) whose method of procedure is as follows: A definite number of cubic centimeters of sugar solution is placed in an Erlenmeyer flask and definite volumes of 0.2 *N* potassium permanganate and of 10 per cent potassium hydroxide solutions are added, and the whole mixture is boiled for ten minutes. After this lapse of time the mixture is cooled to 70° and 20 per cent sulphuric acid and 0.2 *N* oxalic acid solutions are added. The excess oxalic acid is titrated by standard potassium permanganate solution until the pink color can be detected. Their work was principally on the oxidation of lactose, sucrose, glucose, raffinose, mannite, maltose, and hydrolyzed starch. They determined the number of grams of carbon dioxide produced in each case. In the determination of starch, a sample of the air-dry material is dried at 40° C. and the ash, water, protein, pentosans, and fat are determined in this dried matter. The hydrolyzed starch solution obtained by inversion is oxidized as described above. The percentage of starch is calculated on the basis of potassium permanganate used in oxidation. Their results with tapioca and rice give percentages of starch higher by 1 per cent than when determined by difference; that is, by subtracting the sum of the percentages of the other constituents (ash, water, protein, fat, pentosans, etc.) from 100.

EXPERIMENTAL

The experimental part of this paper is discussed under the following heads:

A. Determination of the proper concentration of alkali and potassium permanganate solutions in which to carry on oxidation of glucose.
B. Determination of the optimum temperature and time of heating.
C. Application of the method to glucose determination.
D. Application of the method to starch analysis.
E. Comparison of the Munson and Walker method with the one proposed.

A. DETERMINATION OF THE PROPER CONCENTRATION OF ALKALI AND POTASSIUM PERMANGANATE SOLUTIONS IN WHICH TO CARRY ON OXIDATION OF GLUCOSE

To find the effect of oxidizing known amounts of pure glucose in different concentrations of alkali by 0.2 *N*, 0.1 *N*, and 0.05 *N* potassium permanganate solutions, respectively, experiments were conducted following a procedure similar to that described under C, and using a final volume of 60 cubic centimeters for the mixture.

DISCUSSION OF RESULTS

Table 1 is self-explanatory. The results can be visualized and discussed clearly with the aid of the curves in figs. 1, 2, and 3.

TABLE 1.—*Oxidation of different concentrations of glucose in different concentrations of alkali by 0.2 N, 0.1 N, 0.05 N potassium permanganate solutions, respectively.*

[Figures show amounts in cubic centimeters of potassium permanganate reduced by glucose.]

OXIDATION OF GLUCOSE BY 0.2 *N* POTASSIUM PERMANGANATE.

Glucose.	Concentration of alkali.				
	0.8 *N.*	0.6 *N.*	0.4 *N.*	0.2 *N.*	0.04 *N.*
mg.					
50	26.26	27.24	26.52	30.79	26.57
40	24.03	24.61	24.82	27.56	23.64
30	17.46	19.16	18.42	22.54	17.23
20	13.44	13.47	12.81	16.96	12.44
10	6.27	7.59	6.41	10.81	6.09
OXIDATION OF GLUCOSE BY 0.1 *N* POTASSIUM PERMANGANATE.					
50	21.36	22.13	22.02	22.70	21.80
40	19.89	21.86	20.55	21.61	21.60
30	17.98	21.16	18.58	21.05	20.17
20	16.72	18.59	17.00	17.41	17.26
10	10.32	11.83	11.61	11.60	10.97
OXIDATION OF GLUCOSE BY 0.05 *N* POTASSIUM PERMANGANATE.					
25	25.01	24.22	25.30	25.57	24.95
20	23.00	22.34	24.24	24.95	23.59
15	21.15	21.15	22.92	22.85	22.41
10	20.12	19.46	21.56	21.17	20.15
5	12.37	8.13	10.90	11.04	12.67
2.5	7.12	6.38	8.04	7.71	7.41

These curves bring out the relation between the volume of potassium permanganate solution and the alkali concentration used with varying concentrations of glucose for 0.2 *N*, 0.1 *N*, and 0.05 *N* potassium permanganate, respectively. The curves in figs. 4 and 5 bring out the relation between the amount of glucose used and the value of potassium permanganate reduced in terms of 0.05 *N*. It is apparent that for 0.2 *N* potassium permanganate, 0.2 *N* alkali furnishes the most favorable concentration for the oxidation of glucose. This is shown by curve 4 A, fig. 4, in which all the points are above the others. It is to be noted that the concentration of alkali in all of these experiments is the actual concentration in the mixture, while the normality of the potassium permanganate is that of the standard stock solution used and not that of the mixture. When the concentration of potassium permanganate is 0.1 *N*, 0.6 *N* alkali (curve 2B, fig. 5) seems to furnish the concentration most favorable for the oxidation of glucose, when the amount of the latter in the reaction mixture does not exceed 40 milligrams. In the latter case 0.2 *N* is again the most favorable concentration of alkali. When the concentration of alkali is 0.04 *N* (curve 5B, fig. 5) there seems to be a more uniformly rising curve when the amount of glucose is increased from 10 to 40 milligrams. When the concentration of potassium permanganate is 0.05 *N* (curves C, fig. 5) the differences between the effects of the several concentrations of alkali tend to disappear.

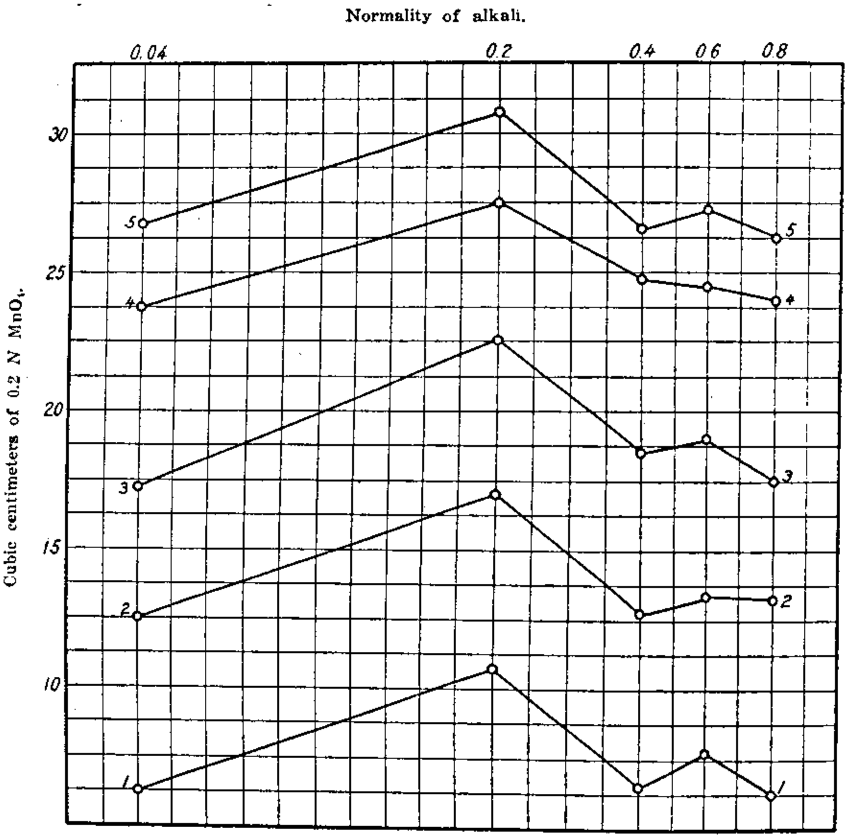

FIG. 1. Effect of normality of alkali on the amount of potassium permanganate in cubic centimeters of 0.2 *N* solution reduced to glucose. Curves 1, 2, 3, 4, and 5 are for 10, 20, 30, 40, and 50 milligrams, respectively.

In choosing the concentrations of alkali and of potassium permanganate to be used in devising a method for the quantitative determination of glucose and starch in agricultural products, I considered the following points:

1. The selection of a concentration which would be least likely to oxidize soluble substances. 0.1 *N* potassium permanganate was chosen, in preference to either the 0.2 *N* or the 0.05 *N*, because it was thought that this concentration would have less chance than would the 0.2 *N* to oxidize soluble substances other than glucose that might be present in the commercial product, and at the same time would give more accurate results; while, on the other hand, it would give a greater range of glucose concentration than the 0.05 *N*.

2. The selection of a concentration of alkali which would give a wider range of concentration of glucose consistent with uniformity of results; 0.04 *N*, as shown by the uniform slope of its curve, fulfills this condition.

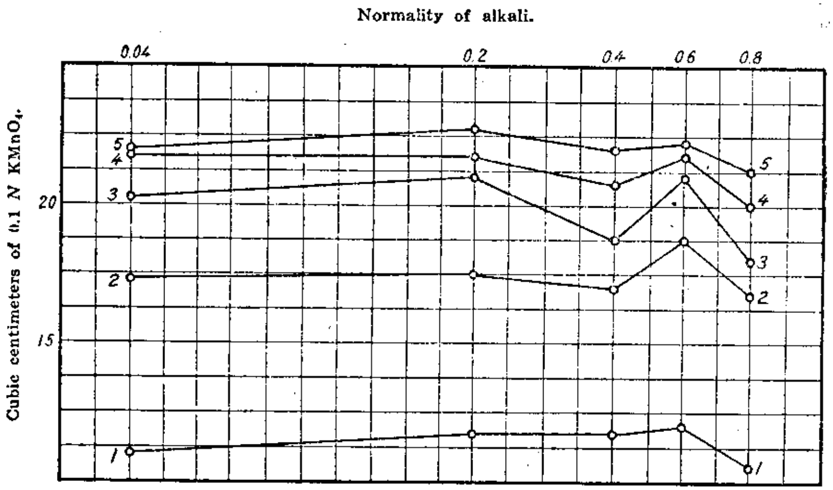

FIG. 2. Effect of normality of alkali on the amount of potassium permanganate in cubic centimeters of 0.1 *N* solution reduced to glucose. Curves 1, 2, 3, 4, and 5 are for 10, 20, 30, 40, and 50 milligrams, respectively.

B. DETERMINATION OF THE OPTIMUM TEMPERATURE AND TIME OF HEATING

STANDARDIZATION OF HEATING POWER

Mechanical arrangement.—The solution is heated in a 400 cubic centimeter Erlenmeyer flask, closed with a two-hole rubber stopper; one hole holds the thermometer, the other an exit tube for the steam. The flask is placed on an asbestos wire gauze over a tripod, and the flame so regulated that it will heat 60 or 100 cubic centimeters of water from 29° to 95° C. in approximately two or four minutes, as the case may be. Draught and consequent changes of temperature are prevented by partially protecting the apparatus with a cylindrical hood of asbestos board. This arrangement of the apparatus is of great advantage because little or no fluctuation of the mercury thread occurs, and air is excluded by the steam arising from the liquid. It is important that the apparatus and its accessories be at room temperature (29° C.) before starting the test.

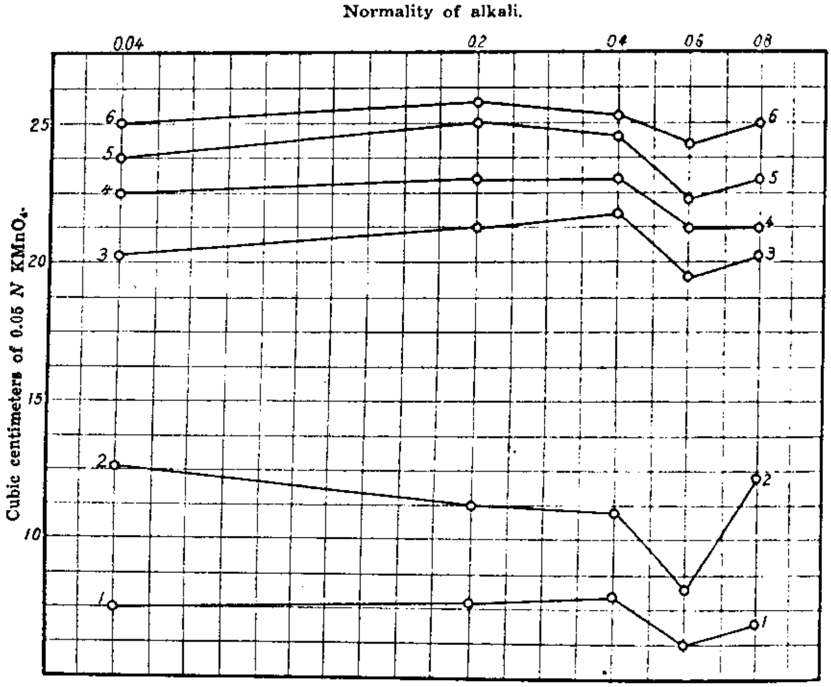

FIG. 3. Effect of normality of alkali on amount of potassium permanganate in cubic centimeters of a 0.05 *N* solution reduced by glucose. Curves 1, 2, 3, 4, 5, and 6 are for 2.5, 5, 10, 15, 20, and 25 milligrams, respectively.

PROCESS OF STANDARDIZATION

In the oxidation process the time of boiling is reckoned from the point when the temperature within the heated liquid is 95° C., rather than from the time when the liquid just begins to boil. Numerous trials show that it is practically impossible to determine exactly by visual observation when the mixture begins to boil. There is an easily measurable interval during which an observer cannot decide from what point he shall reckon the time of boiling. The appearance of bubbles does not usually indicate the beginning of boiling because bubbles of gas escape at irregular intervals before real boiling takes place. Slight

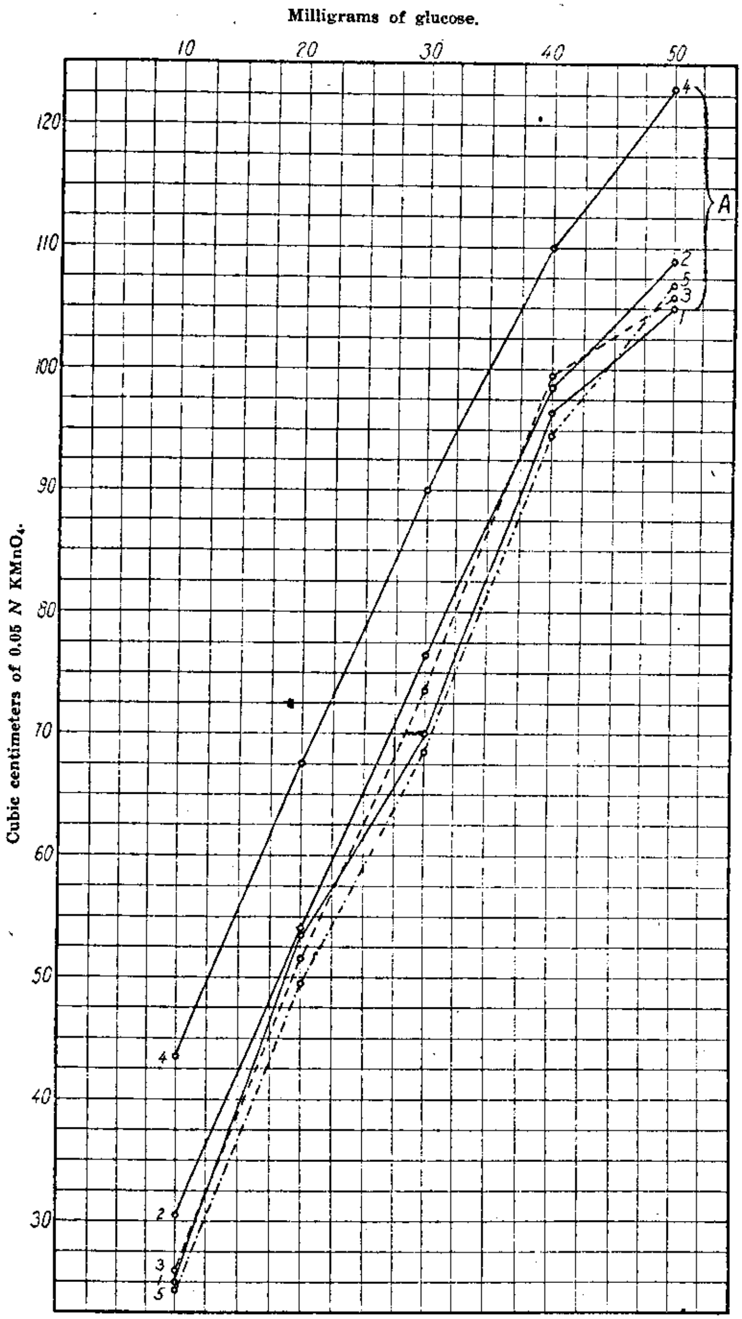

FIG. 4. Relation between milligrams of glucose and cubic centimeters of 0.05 *N* potassium permanganate solution reduced. Curves A are for 0.2 *N* potassium permanganate; curve 1 is for 0.8 *N* alkali solution; curve 2, for 0.6 *N* solution; curve 3, for 0.4 *N* solution; curve 4, for 0.2 *N* solution; curve 5, for 0.04 *N* solution.

deviations from this standard are negligible if only small quantities of glucose are involved in the analysis; but they become of great importance when relatively large amounts are present in the solution.

Experiments show that the mercury thread begins to fluctuate approximately thirty seconds after the thermometer reaches 95°. The temperature at the end of the thirty seconds, and just when fluctuation begins, has been observed to be about 104° to 105° C. when the dilution is 100 cubic centimeters, and 110° C. when the dilution is 60 cubic centimeters. Boiling of the solution starts within 5° before fluctuation begins. At this point, the rise of temperature is in most cases so rapid that it is impossible to time it accurately.

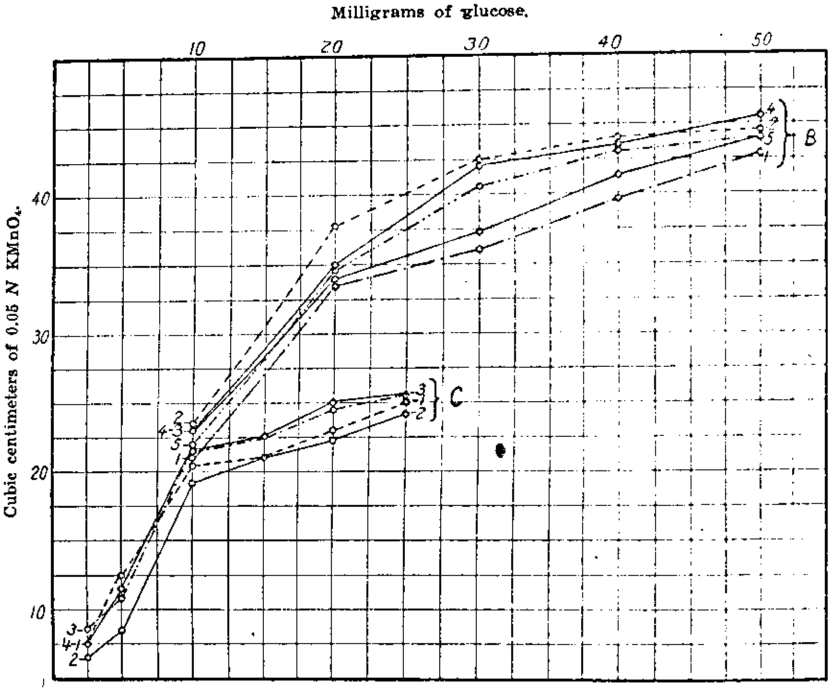

FIG. 5. Relation between milligrams of glucose and cubic centimeters of 0.05 *N* potassium permanganate solution reduced. Curves B are for 0.1 *N* and curves C, for 0.05 *N* potassium permanganate. Curve 1 is for 0.8 *N* alkali solution; curve 2, for 0.6 *N* solution; curve 3, for 0.4 *N* solution; curve 4, for 0.2 *N* solution; curve 5, for 0.04 *N* solution.

THE INFLUENCE OF TIME AND TEMPERATURE UPON THE OXIDATION

A series of experiments was performed to determine the influence of temperature and time of heating upon the degree of oxidation of glucose, using 0.1 N alkaline potassium permanganate solution. The total number of cubic centimeters of 0.1 N potassium permanganate used for oxidation was obtained by heating the alkaline potassium permanganate mixtures of the same composition to different temperatures, and for different lengths of time after 95° C. had been reached. The results are given in Tables 2, 3, and 4.

TABLE 2.—*Glucose oxidation by potassium permanganate at various temperatures rising from 29° to 95° C. in four minutes.*

[For final volume of mixture of 60 cubic centimeters.]

Observation.	Temperature.	Time of heating.		0.1 N potassium permanganate.	Oxidation.
	°C.	*Min.*	*sec.*	*cc.*	*Per cent.*
1	60	1	36	6.53	49.69
2	70	2	02	7.50	56.82
3	80	2	48	9.05	68.56
4	90	4	32	10.57	80.07
5	95	4	41	10.59	80.02
6			[a]30	10.80	81.81
7			[a]60	11.12	84.50
8			[a]90	11.18	84.70
9			[a]120	11.47	86.96
10			[a]150	11.45	86.96
11			[a]180	11.50	87.01

[a] Length of time after 95° C. had been reached.

TABLE 3.—*Glucose oxidation by potassium permanganate at various temperatures rising from 29° to 95° C. in two minutes.*

[For final volume of mixture of 60 cubic centimeters.]

Observation.	Temperature.	Time of heating.		0.1 N potassium permanganate.	Oxidation.
	°C.	*Min.*	*sec.*	*cc.*	*Per cent.*
1	60	0	45	5.60	42.42
2	70	1	00	6.15	46.50
3	80	1	15	6.70	50.76
4	90	1	45	8.30	62.87
5	95	2	00	9.10	68.94
6		0	[a]30	10.25	77.65
7		0	[a]60	10.77	81.60
8		0	[a]90	11.10	84.10
9		0	[a]120	11.23	85.10
10		0	[a]150	11.45	86.72
11		0	[a]180	11.52	87.04

[a] Length of time after 95° C. had been reached.

TABLE 4.—*Glucose oxidation by potassium permanganate at various temperatures rising from 29° to 95° C. in two minutes.*

[For final volume of mixture of 100 cubic centimeters.]

Observation.	Temperature.	Time of heating.	0.1 N potassium permanganate.	Oxidation.
	°C	*Min. sec.*	*cc.*	*Per cent.*
1	60	0 55	8.55	64.77
2	70	1 15	8.55	64.77
3	80	1 30	9.68	73.33
4	90	1 50	10.18	77.12
5	95	2 00	10.93	82.80
6		[a]30	11.50	87.12
7		[a]60	11.80	89.39
8		[a]90	12.04	91.21
9		[a]120	12.08	91.51
10		[a]180	12.53	94.92

[a] Length of time after 95° C. had been reached.

Table 2 shows the volumes of 0.1 N potassium permanganate used to oxidize 10 milligrams of dextrose at different intervals of temperature for a total volume of 60 cubic centimeters and with heating power so regulated that it raises the temperature of the mixture from 29° to 95° C. in exactly four minutes. In all determinations ten or eleven quadruplicate observations were made. Column four shows the actual number of cubic centimeters of potassium permanganate used for oxidation, and column five gives these same values in percentage of the volume of 0.1 N potassium permanganate solution required for the complete oxidation to carbon dioxide and water of 10 milligrams of glucose. For each determination blanks were run, and the values in column four are actual values minus the corrections for the average blanks.

Tables 3 and 4 are similar to Table 2, but the heating power here is that required to raise the temperature of the mixture, 60 cubic centimeters and 100 cubic centimeters, respectively, from 29° to 95° C. in exactly two minutes.

Tables 2 and 3 were prepared by oxidizing the glucose with 25 cubic centimeters of 0.1 N potassium permanganate solution diluted to a final volume of 60 cubic centimeters, while Table 4 was obtained by using 50 cubic centimeters of 0.1 N potassium permanganate diluted to a final volume of 100 cubic centimeters. The procedure followed was that described under C, with corresponding modifications.

The data in these tables are visualized in fig. 6 in which the abscissas represent the temperatures and time intervals, and the ordinates the values given in column four. The curves in fig. 6 show in a general way that the percentage of glucose oxidized increases with increase in temperature and in time of heating. Curve 1 indicates, however, that the reaction does not proceed as regularly with the longer time of heating as with the shorter. The percentages of glucose oxidized are higher in Table 4 than in Tables 2 and 3, because the concentration of potassium permangate is larger in the mixture for Table 4 than for the other two.

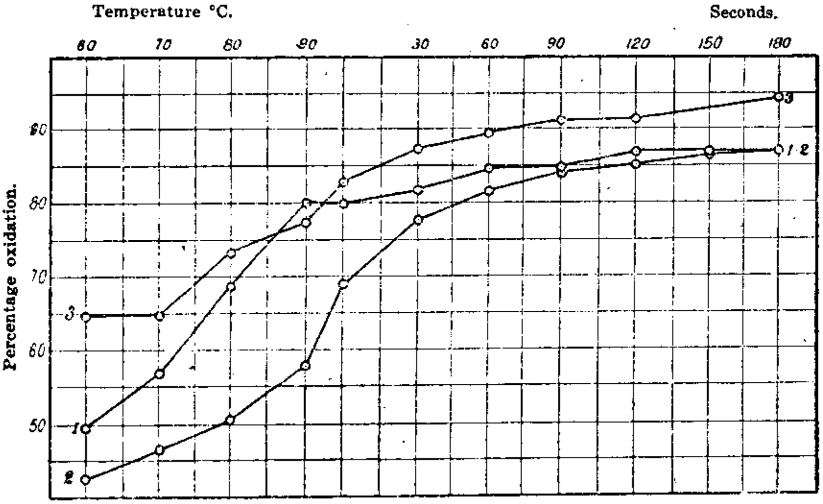

FIG. 6. Effect of temperature and length of heating on the percentage of glucose oxidation by 0.1 *N* potassium permanganate solution. Curve 1 is for heating power of four minutes and volume of mixture of 60 cubic centimeters. Curves 2 and 3 are for heating power of two minutes and for 60 and 100 cubic centimeters, respectively.

In view of these results the conditions in Table 4 have been adopted as standard for the proposed method:

a. 100 cubic centimeters for the final volume of the mixture.

b. A heating power so regulated that it will raise the temperature of 100 cubic centimeters of the mixture from 29° to 95° C. in exactly two minutes.

c. A total time of heating of four minutes: two minutes to raise the temperature from 29° to 95° C. and two minutes more thereafter.

C. APPLICATION OF THE METHOD TO GLUCOSE DETERMINATION

METHOD OF PROCEDURE

Place 50 cubic centimeters of 0.1 *N* potassium permanganate, 25 cubic centimeters of a solution of sodium carbonate containing 8.48 grams of anhydrous sodium carbonate per liter, and

25 cubic centimeters of the glucose or hydrolyzed starch solution in an Erlenmeyer flask, or 10 cubic centimeters of the solution to be analyzed and 15 cubic centimeters of distilled water, to make the volume exactly 100 cubic centimeters. Place the flask on the heating device described on page 587 with the heating power so regulated that its temperature is raised from 29° to 95° C. in two minutes, and heat it for exactly two minutes after the temperature has reached 95°C. Remove the flask and add gradually 25 cubic centimeters of 28 per cent sulphuric acid and 25 cubic centimeters of 0.1 *N* oxalic acid solutions. Titrate the excess of oxalic acid against standard potassium permanganate solution, adding the latter until the liquid assumes a pink color which it retains for a few seconds. The sum of the number of cubic centimeters of 0.1 *N* potassium permanganate used in oxidation and in titration minus the number of cubic centimeters of 0.1 *N* oxalic acid solution used gives the total number of cubic centimeters of 0.1 *N* potassium permanganate actually used in oxidation.

Table 5 was prepared with pure glucose. The glucose was obtained by repeated crystallization of Kahlbaum's Traubenzucker from methyl alcohol. It was dissolved in the least pos-

TABLE 5.—*For calculating the weight of glucose and starch from the volume of 0.1 N potassium permanganate.*

0.1 *N* potassium permanganate.	Glucose.	Starch.	0.1 *N* potassium permanganate.	Glucose.	Starch.
cc.	*mg.*	*mg.*	*cc.*	*mg.*	*mg.*
5.40	4	3.72	27.88	23	21.39
6.54	5	4.65	28.48	24	22.32
7.68	6	5.58	29.47	25	23.25
8.76	7	6.51	30.46	26	24.18
9.84	8	7.44	31.67	27	25.11
11.08	9	8.39	32.88	28	26.04
12.32	10	9.30	33.81	29	26.97
13.45	11	10.23	34.75	30	27.90
14.58	12	11.16	35.80	31	28.83
15.75	13	12.09	36.86	32	29.76
16.93	14	13.02	37.58	33	30.69
17.85	15	13.92	38.24	34	31.62
18.77	16	14.88	39.38	35	32.55
20.13	17	15.81	40.52	36	33.48
21.49	18	16.74	41.05	37	34.41
22.74	19	17.67	41.58	38	35.34
23.99	20	18.60	42.22	39	36.17
25.13	21	19.53	42.86	40	37.20
26.28	22	20.46	43.35	41	38.13

sible amount of methyl alcohol and the solution thus obtained was treated with a few cubic centimeters of ether until crystals began to appear. The vessel was then placed in a desiccator over concentrated sulphuric acid and the alcohol allowed to evaporate slowly. The crystals were separated from the mother liquor by suction and washed with small amounts of methyl alcohol and ether, and then dried at 40° C. under vacuum in an apparatus similar to that described in Browne's Handbook of Sugar Analysis, page 23.

D. APPLICATION OF THE METHOD TO STARCH ANALYSIS

DIRECT ACID HYDROLYSIS (MODIFIED TO SUIT CONDITIONS FOR OXIDATION WITH POTASSIUM PERMANGANATE), APPLICABLE TO GLUCOSE AND COMMERCIAL STARCH

Stir a 2- to 3-gram sample of the dry material in a beaker with 50 cubic centimeters of cold water for an hour. Transfer to a filter and wash with 250 cubic centimeters of cold water. Heat the insoluble residue for from three to four hours with 200 cubic centimeters of water and 15 cubic centimeters of sulphuric acid (specific gravity, 1.84) in a flask provided with a reflux condenser. Cool and neutralize exactly with sodium hydroxide solution. Complete the volume to 500 cubic centimeters, filter, and determine the dextrose in an aliquot of the filtrate as directed under the described method of procedure. The number of milligrams of dextrose, or its equivalent in starch in solution, corresponding to the number of cubic centimeters of 0.1 *N* potassium permanganate used by the samples, will be given by the corresponding values in Table 5, by interpolation if necessary.

The factor 0.9 is the theoretical ratio between starch and glucose but, according to Noyes (11) and other investigators, the factor 0.93 more nearly approaches the actual value. The factor 0.93 is used in this work.

THE SALIVA METHOD, (7) APPLICABLE TO ALL PRODUCTS CONTAINING STARCH

The direct acid hydrolysis method just described cannot be applied to the analysis of flour or other plant products containing substances other than starch, as will be seen in Table 6. If, however, the diastase or saliva method is used, results that are comparable with those by the Munson and Walker method are obtained.

Saliva contains the ferment ptyalin, which possesses the power of bringing starch into solution by converting it into dextrin and finally into maltose.

Procedure.—Collect saliva by chewing a piece of paraffin. Filter and neutralize exactly with dilute hydrochloric acid. Heat the gelatinized starch to 40° C., add 25 cubic centimeters of saliva, and allow the solution to remain at 40° C. until a drop of the liquid gives no test for starch with iodine solution. Filter the solution, make the volume to 200 cubic centimeters hydrolyze by the acid hydrolysis method and determine starch in the hydrolysate by the alkaline potassium permanganate method.

Blank determination.—Take an amount of saliva equal to that used in the determination of starch, dilute to 200 cubic centimeters, and proceed as in the determination of starch as given above.

E. COMPARISON OF THE MUNSON AND WALKER METHOD WITH THE ONE PROPOSED

To test the accuracy of the proposed method parallel determinations were run with it and with the Munson and Walker method, using pure glucose, commercial starch, and air-dry flour prepared from some tubers. The analyses of pure glucose are shown below with details given in full. The results with starch and flour are given in Table 6.

ANALYSIS OF PURE GLUCOSE, BY THE MUNSON AND WALKER METHOD

The Munson and Walker method (12) was followed.

Sample 1.—0.4900 gram of glucose was dissolved in 110 cubic centimeters of distilled water and 10 cubic centimeter portions were taken for analysis.

Weight of cuprous oxide.

	Samples. Grams.	Blanks.[a] Grams.
	0.2110	....
	0.2110	0.1083
	0.2116	0.1096
	0.2132	0.1070
	0.2076	....
Average,	0.2109	0.1083

[a] The Rochelle salt solution used in these determinations happened to be an old one, and this is the reason why blanks are very high.

Total weight of cuprous oxide from 10 cubic centimeters of glucose solution, 102.6 milligrams.

102.6 milligrams cuprous oxide, 44.5 milligrams glucose.

Glucose found by analysis, 99.89 per cent.

Sample 2.—0.500 gram of glucose was dissolved in 100 cubic centimeters of distilled water, and 10 cubic centimeter portions were taken for analysis.

Weight of cuprous oxide.

	Samples. Grams.	Blanks. Grams.
	0.1125	0.0015
	0.1141	0.0017
	0.1136	0.0016
	0.1134	....
	0.4536	0.0048
Average,	0.1135	0.0016

Total weight of cuprous oxide from 10 cubic centimeters of glucose solution, 111.9 milligrams.

111.9 milligrams cuprous oxide, 48.6 milligrams glucose.

Glucose found by analysis, 99.20 per cent.

ANALYSIS OF PURE GLUCOSE, BY THE ALKALINE POTASSIUM PERMANGANATE METHOD

Sample 1.—0.100 gram of glucose was dissolved in 100 cubic centimeters of distilled water, and 10 cubic centimeter portions were taken for analysis.

Ten milligrams of glucose required 12.34 cubic centimeters of 0.1 *N* potassium permanganate solution.

12.34 cubic centimeters of 0.1 *N* potassium permanganate according to values in Table 5 are equivalent to 10.02 milligrams of glucose.

Glucose found by analysis, 100.2 per cent.

Sample 2.—0.500 gram of glucose was dissolved in 100 cubic centimeters of distilled water, and 5 cubic centimeter portions were taken for analysis.

25 milligrams of glucose required 29.24 cubic centimeters 0.1 *N* potassium permanganate solution.

29.24 cubic centimeters 0.1 *N* potassium permanganate according to values in Table 5 are equivalent to 24.76 milligrams dextrose.

Glucose found by analysis, 99.04 per cent.

Table 6 shows that the alkaline potassium permanganate used with the direct acid hydrolysis method for the determination of starch in flour gives results that are about 10 per cent higher than those obtained with the Munson and Walker method. This is undoubtedly due to oxidation of soluble substances present in the flour. With commercial starch preparation, the results by the two methods differ by 0.65 per cent, although at times the difference may reach 1 per cent. The determination of flour by hydrolosis with saliva gives results by the two methods which agree very closely.

SUMMARY

The extent to which glucose is oxidized by constant concentration of potassium permanganate varies for the same concentration of glucose with change in the concentration of alkali. In the case of a mixture of 25 cubic centimeters of 0.2 *N* potassium

TABLE 6.—*Analysis of starch and flour by the Munson and Walker and the alkaline potassium permanganate methods.*

Sample No.	Name of sample.	Munson and Walker method.		Alkaline potassium permanganate method.	
		Direct acid hydrolysis method.	Saliva method.	Direct acid hydrolysis method.	Saliva method.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	Corn starch	79.79	----------	80.35	----------
2	Do	79.98	----------	80.89	----------
3	Do	83.71	----------	82.96	----------
4	Do	78.89	----------	79.18	----------
5	Cassava starch.	79.52	----------	78.76	----------
6	Do	79.43	----------	80.43	----------
7	Do	78.70	----------	78.01	----------
8	Do	78.20	----------	77.72	----------
9	Do	78.70	----------	77.88	----------
10	Do	78.90	----------	78.03	----------
11	Arrowroot flour	77.79	----------	84.00	----------
12	Do	78.90	68.83	84.04	70.39
13	Rice flour	70.94	----------	76.58	----------
14	Banana flour	56.88	----------	66.75	----------
15	*Dioscorea doemona* flour	56.88	45.21	68.28	45.32
16	*Dioscorea alata* flour	66.49	60.13	72.86	59.89

permanganate in a volume of 100 cubic centimeters, 0.2 *N* alkali is found to be the concentration most favorable for the oxidation of glucose, the extent to which this sugar is oxidized declining when the concentration of alkali is changed from this point. In the case of 0.1 *N* potassium permanganate, there are two concentrations of alkali most favorable for the oxidation of glucose; these are 0.6 *N* and 0.2 *N*. The results obtained in these experiments on the concentration of alkali most favorable for the oxidation of glucose by potassium permanganate agree with those of the previous work on the subject. The amount of potassium permanganate used increases uniformly with increasing amount of glucose from 1 to 40 milligrams only when the concentration of alkali is 0.04 *N*. This is the main reason for choosing this concentration of alkali, for with it more accurate and consistent results and a wider range of concentration of glucose can be obtained. One-tenth *N* potassium permanganate was chosen in preference to 0.2 *N* because it was thought that the former concentration would have less power to oxidize organic substances other than glucose when the method is applied to agricultural products, and it will surely give more accurate results.

A new method for the analysis of starch and glucose has been developed and applied to the determination of starch in commercial starch and flour. The method would give results as accurate as the Munson and Walker method with commercial starch. However, it cannot be used with flour with the acid hydrolysis method. For the determination of the latter, the saliva or the diastase method should be used. In either case, the alkaline potassium permanganate is practically as reliable as the Munson and Walker method.

CONCLUSIONS

1. A method for the determination of glucose and starch has been developed.
2. A description of the method is given.
3. The method is applicable to commercial starch, whether hydrolyzed by acid or by diastase.
4. When the flour is analyzed, it should be hydrolyzed by the saliva or the diastase method. If it is hydrolyzed by acid, the results obtained by the new method are about 10 per cent higher than those obtained by the Munson and Walker.
5. Some of the results obtained in these experiments on the concentration of alkali most favorable to the oxidation of glucose by alkaline potassium permanganate agree with those of the previous work on the subject.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Chart, showing the effect of normality of alkali on the amount of potassium permanganate in cubic centimeters of 0.2 *N* solution reduced to glucose.
2. Chart, showing the effect of normality of alkali on the amount of potassium permanganate in cubic centimeters of 0.1 *N* solution reduced to glucose.
3. Chart, showing the effect of normality of alkali on amount of potassium permanganate in cubic centimeters of a 0.05 *N* solution reduced to glucose.
4. Chart, showing relation between milligrams of glucose and cubic centimeters of 0.05 *N* potassium permanganate solution reduced. See also fig. 5.
5. Chart, showing relation between milligrams of glucose and cubic centimeters of 0.05 *N* potassium permanganate solution reduced. See also fig. 4.
6. Chart, showing effect of temperature and length of heating on the percentage of glucose oxidation by 0.1 *N* potassium permanganate solution.

THE GROWTH OF RICE AS RELATED TO PROPORTIONS OF FERTILIZER SALTS ADDED TO SOIL CULTURES

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FIVE TEXT FIGURES

INTRODUCTION

The essential mineral elements that must enter through the plant roots are nitrogen, potassium, phosphorus, magnesium, calcium, iron, and sulphur. Soils that support plant growth contain all of these elements in suitable compounds. Three of them—magnesium, sulphur, and iron—are usually present in the soil in amounts beyond what the plants need. The elements that are likely to be present in insufficient quantities, or that usually produce marked improvement in plant growth when added to the soil, are phosphorus, nitrogen, potassium, and calcium.(12) Calcium is most frequently added in fertilizer practice as limestone ($CaCO_3$) or as gypsum ($CaSO_4$); and it is the indirect effects of these calcium salts upon the soil that are commonly beneficial, rather than the added supply of calcium as such.

The present study deals with the growth of rice plants in soil cultures to which the three very important elements, phosphorus, nitrogen, and potassium, were added in various proportions. The addition of these elements was made by means of the three salts, primary calcium phosphate [$Ca(H_2PO_4)_2$], ammonium sulphate [$(NH_4)_2SO_4$], and potassium sulphate (K_2SO_4). These three salts are largely used in commercial fertilizers. Primary calcium phosphate is commonly used to supply phosphorus, ammonium sulphate to supply nitrogen, and potassium sulphate to supply potassium. Besides the three elements just mentioned, sulphur and calcium also are added when these fertilizer salts are used. These three fertilizer salts actually contain all of the essential elements for plants except iron and magnesium, and in agricultural work a mixture of the three compounds would be called a complete fertilizer.

In the experiments here reported the three salts were added to the soil in thirty-six different sets of proportions, including all possible sets of proportions with each salt varying in amount, from set to set, by increments of 0.1 of the total salt content of the mixture, which was osmotically the same in all the sets. For these tests rice was employed, growing in a water-saturated soil, in culture vessels having a capacity of approximately 19 liters each. The present experiments are of a preliminary nature; but no previously reported work has dealt with the range of possible sets of proportions in the way here followed, and the results may be valuable to other workers. The study was carried out at the College of Agriculture, at Los Baños, during the period from June to October, 1918, which comprises the most favorable season for the growth of rice in this part of the Philippine Islands. It is a pleasure to acknowledge indebtedness to Prof. B. E. Livingston, of Johns Hopkins University, for aid in the preparation of this paper; and to P. David and F. de Peralta for assistance in the experimentation.

The rice plants were grown to maturity. The total osmotic value of the salts added to the soil was always calculated to be the same, the unit of variation being 0.1 of this calculated value. This method is similar to that already employed in solution cultures and in sand cultures by various workers.[1] In the present experiments with water-saturated soil the salts were supplied in addition to those already present in the soil. To each culture a sufficient quantity of salts was added to give in 19 liters of water a total osmotic concentration of approximately 0.5 atmosphere at 25° C.[2]

It is of course realized that, after addition to the soil, the salts were immediately altered to a greater or less degree by chemical changes and absorption. But so little is known concerning such alterations that they cannot be quantitatively discussed as yet.

The thirty-six different salt combinations may be represented by means of a triangular diagram like that described by Shive in the papers already cited. Such a diagram is shown in fig. 1. In this triangular diagram each of the intersections of lines represents one of the salt combinations used. The lowest row of intersections (R1) represents combinations in which 0.1 of the total osmotic concentration is due to primary calcium phosphate; the second row (R2) represents those having 0.2 due to primary calcium phosphate, etc.; while the apex of the triangle (R8) has 0.8 due to primary calcium phosphate. Similarly, the line forming the left-hand margin of the triangle represents combinations in which 0.1 of the osmotic value is due to ammonium sulphate, while the angle at the extreme right represents a combination having 0.8 due to this salt. Likewise, the line at the right-hand margin denotes combinations in which 0.1 of the total osmotic value is due to potassium sulphate, while the angle at the extreme left denotes a combination in which 0.8 are due to this salt. Following the method employed by Shive, each culture is designated by the row number and the number of the culture within the row—for example, R1C5. The salt mixture for this culture has 0.1 of its total osmotic value due to primary calcium phosphate, 0.5 due to ammonium sulphate, and 0.4 due to potassium sulphate.

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[1] See the articles by Tottingham,(15) by Shive,(13, 14) and McCall(10) that are cited at the end of this paper.

[2] The culture medium was composed of approximately 19 liters of water-saturated soil. It contained approximately 16,000 grams of moisture-free soil and 12,000 cubic centimeters of solution. The quantity of salt added to each culture was calculated to give approximately 0.5 atmosphere osmotic concentration in 19 liters of solution; this would give approximately 0.79 atmosphere in 12,000 cubic centimeters.

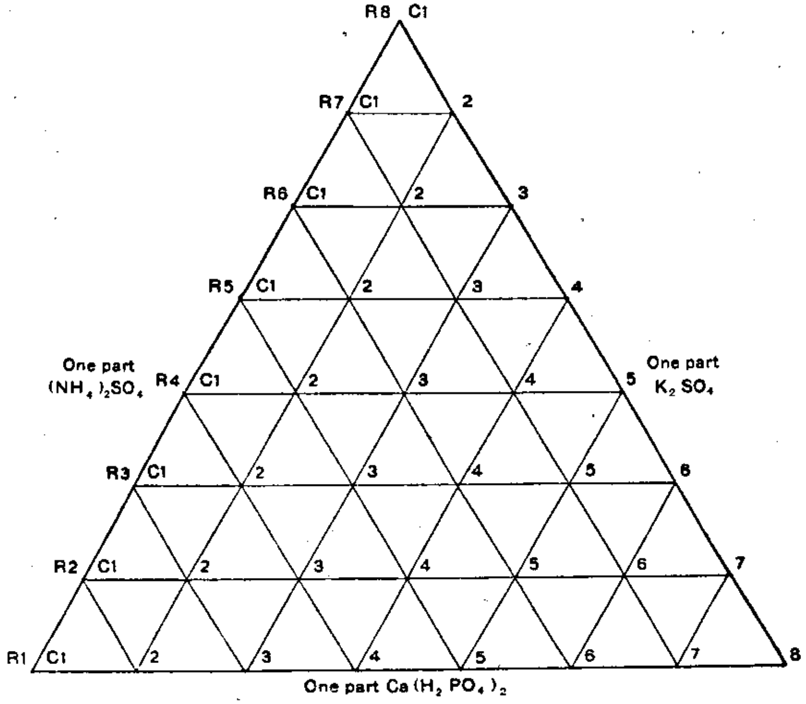

FIG. 1. Culture numbers and osmotic proportions of the three salts.

TABLE 1.—*Number of gram molecules of each salt required in 1 liter of water, to produce from 0.1 to 0.8 of a total osmotic concentration of approximately 0.5 atmosphere.*

Tenths of 0.5 atmosphere.	$Ca(H_2PO_4)_2$.	$(NH_4)_2SO_4$.	K_2SO_4.
1	0.00081	0.00081	0.00081
2	0.00161	0.00161	0.00161
3	0.00242	0.00242	0.00242
4	0.00323	0.00323	0.00323
5	0.00404	0.00404	0.00404
6	0.00485	0.00485	0.00485
7	0.00566	0.00566	0.00566
8	0.00647	0.00647	0.00647

The amount of each salt needed to produce the required partial concentrations has been approximately calculated by means of the van't Hoff equation for osmotic pressure. The general method used in such calculations is presented in detail in the paper by Tottingham previously mentioned. Table 1 gives the calculated number of gram molecules of each salt required to produce from 0.1 to 0.8 of the total osmotic concentration of approximately 0.5 atmosphere in 1 liter of water. The culture medium used was composed of saturated soil with water standing to a depth of about 3 centimeters on the surface, and occupied a volume of approximately 19 liters. Accordingly, the values given in Table 1 were multiplied by 19 to obtain the amount of each salt required for each of the thirty-six cultures of these tests. The values thus calculated are shown in Table 2, where they are expressed both in terms of gram molecules and in terms of grams, for each of the salts.

TABLE 2.—*Amount of each salt, expressed in grams and in gram molecules, that was added to the 19 liters of water-saturated soil of each culture.*

Tenths of 0.5 atmosphere.	$Ca(H_2PO_4)_2$.		$(NH_4)_2SO_4$.		K_2SO_4.	
	gm. mol.	*gm.*[a]	*gm. mol.*	*gm.*	*gm. mol.*	*gm.*
1	0.0154	3.60	0.0154	2.03	0.0154	2.68
2	0.0307	7.19	0.0307	4.05	0.0307	5.35
3	0.0461	10.78	0.0461	6.08	0.0461	8.02
4	0.0614	14.37	0.0614	8.11	0.0614	10.70
5	0.0768	17.97	0.0768	10.14	0.0768	13.38
6	0.0922	21.57	0.0922	12.16	0.0922	16.05
7	0.1075	25.15	0.1075	14.19	0.1075	18.73
8	0.1228	28.75	0.1228	16.22	0.1228	21.40

[a] Grams of the anhydrous salt.

TABLE 3.—*Culture numbers and composition of each of the salt combinations. Also, average height of the plants at time of flowering; relative air-dry yield of tops; relative air-dry yield of grain; relative number of fruiting panicles—for two plants.*

Culture No.	Amount of salts.			Growth and yield data for two plants.			
	$Ca(H_2PO_4)_2$.	$(NH_4)_2SO_4$.	K_2SO_4.	Relative average height of plants, Sept. 17.	Relative dry yield of tops.	Relative yield of grain.	Fruiting panicles.
	gm. mol.	*gm. mol.*	*gm. mol.*	*cm.*	*gm.*	*gm.*	
R1C1	0.0154	0.0154	0.1228	59 L	21 L	20 L	26 L
R1C2	0.0154	0.0307	0.1075	76	39	42	33 L
R1C3	0.0154	0.0461	0.0922	83	53	60	39
R1C4	0.0154	0.0614	0.0768	90	72	67	37
R1C5	0.0154	0.0768	0.0614	91H	79H	52	52
R1C6	0.0154	0.0922	0.0461	91H	84H	96H	52
R1C7	0.0154	0.1075	0.0307	93H	88H	91H	67H
R1C8	**0.0154**	**0.1228**	**0.0154**	**96H**	**100H**	**100H**	**100H**
					[b](206)	[b](140)	(54)
R2C1	0.0307	0.0154	0.1075	72 L	23 L	20 L	26 L
R2C2	0.0307	0.0307	0.0922	74 L	35 L	41	37
R2C3	0.0307	0.0461	0.0768	78	50	46	39
R2C4	0.0307	0.0614	0.0614	88	68	56	50
R2C5	0.0307	0.0768	0.0461	97H	85H	68	72H
R2C6	0.0307	0.0922	0.0307	98H	93H	94H	70H
R2C7	0.0307	0.1075	0.0154	88	67	76H	48
R3C1	0.0461	0.0154	0.0922	68 L	21 L	20 L	24 L
R3C2	0.0461	0.0307	0.0768	74 L	40	22 L	37
R3C3	0.0461	0.0461	0.0614	80	57	56	46
R3C4	**0.0461**	**0.0614**	**0.0461**	**100H**	65	70	56H
				[a](138)			
R3C5	0.0461	0.0768	0.0307	94H	78	79H	65H
R3C6	0.0461	0.0922	0.0154	91H	96H	93H	70H
R4C1	0.0614	0.0154	0.0768	69 L	23 L	23 L	24 L
R4C2	0.0614	0.0307	0.0614	86	48	41	39
R4C3	0.0614	0.0461	0.0461	94H	54	59	46
R4C4	0.0614	0.0614	0.0307	94H	62	74H	43
R4C5	0.0614	0.0768	0.0154	89	87H	86H	69H
R5C1	0.0768	0.0154	0.0614	78	34 L	32	32 L
R5C2	0.0768	0.0307	0.0461	77	37	41	33 L
R5C3	0.0768	0.0461	0.0307	90	46	53	39
R5C4	0.0768	0.0614	0.0154	88	81H	74H	56H
R6C1	0.0922	0.0154	0.0461	85	32 L	25 L	28 L
R6C2	0.0922	0.0307	0.0307	74 L	41	39	35
R6C3	0.0922	0.0461	0.0154	62 L	21 L	23 L	28 L
R7C1	0.1075	0.0154	0.0307	71 L	30 L	29 L	33 L
R7C2	0.1075	0.0307	0.0154	85	64	51	52
R8C1	0.0128	0.0154	0.0154	70 L	35 L	23 L	41
Control 1				56 L	16 L	17 L	22 L
Control 2				57 L	20 L	15 L	22 L
Control 3				58 L	22 L	22 L	32 L
Average control				57 L	19 L	18 L	25 L

[a] Actual height in centimeters.

[b] Actual yield in grams.

The culture numbers and sets of salt proportions in each of the cultures actually used in this work are shown in Table 3. The culture numbers are shown in the first column, and the numbers of gram molecules of each of the three salts are shown in the three following columns. Besides the cultures supplied with fertilizers, three control cultures, which had no addition of salts, were included in the series.

The soil used in these tests was a clay loam collected from the college mulberry plantation, near the seed laboratory. Into each culture vessel (an ordinary 5-gallon, tin petroleum can) were placed approximately 20 kilograms of thoroughly mixed soil. The fertilizer salts were added to the cultures on July 4, 1918. This was done by first preparing stock solutions of each of the salts with rain water. The necessary amount of each stock solution was then added to three liters of water, and the solution thus obtained was thoroughly mixed with the soil of the culture.

The rice employed in the present study was of the variety known as *sanglay puti*, a variety sometimes grown as a lowland rice with continuous irrigation, but more frequently grown as an upland rice, without irrigation and depending on the precipitation of the rainy season. The seeds used had been harvested on October 13, 1917, from a crop grown on the college farm. They were soaked in water for twenty-four hours and were planted on June 8, 1918, in shallow seed boxes. The seeds germinated on June 10, and made uniform and healthy growth. On July 6, when three leaves had developed, eight apparently similar seedlings were transplanted to each of the culture vessels, the soil having been previously prepared and the salts added as above described. After transplanting the seedlings the soil in each culture was saturated with water. The cultures were allowed to remain in the shade until July 16, when they were transferred to full sunlight in a location where they were all exposed to nearly uniform conditions of light and wind. They were watered every day in order to maintain an approximately constant water level—about 3 centimeters above the soil surface—in all of the cans. On July 26, four plants were removed from each culture, leaving the four largest plants. On July 31, two more plants were removed, leaving the two largest plants in each culture. Harvest occurred on October 16, 1918, the grain and tops being collected separately, and the number of fruiting panicles in each culture being recorded. The grain and tops were allowed to become air-dry, after which the final weighings were made.

EXPERIMENTAL RESULTS

APPEARANCE OF THE PLANTS

The plants in all of the cultures made vigorous growth. Within a week after transplanting many of the cultures were observed to be growing more rapidly than the control cultures, and these differences became more marked as the experiment continued. Although the plants that had received fertilizer grew more rapidly than those of the control cultures, even the latter made rather good growth and appeared nearly as vigorous as plants growing in the field. Besides these differences in rate of growth, differences in color were noted, these becoming conspicuous about three weeks after transplanting. At this time the cultures having 0.1 and 0.2 of their total osmotic concentration due to ammonium sulphate were small and were light green in color; those having 0.3, 0.4, and 0.5 due to ammonium sulphate were a medium shade of green; and the cultures having 0.6, 0.7, and 0.8 of their total concentration due to this salt were a very dark shade of green. The plants that were medium and those that were dark in color were apparently the most vigorous and made the most rapid vegetative growth; they also produced the largest numbers of stools and the broadest leaves. It is thus suggested that the greenness and breadth of the leaves and the number of stools were roughly proportional to the ammonium sulphate content of the fertilizer mixture. These differences in color remained noticeable until several weeks after the time of flowering, when all of the cultures became yellower in color and the differences became less marked.

Flowering began in the first week in September. There was no very great difference between the various cultures in the time of flowering. Within a week after the first flowers appeared most of the plants had developed flowers, and within two weeks all of the plants were in bloom.

MEASUREMENT OF PLANT GROWTH

In order to obtain an approximate measurement of the rates of growth, the height of the tallest leaf in each plant was measured at weekly intervals. These measurements need not all be presented here, but those made on September 17, when most of the plants had reached approximately their maximum size and had begun to produce flowers, may be considered. The measurements are given in the fifth column of Table 3; each one represents the average of the two measurements made for each culture on this date. To facilitate comparison the values are expressed as relative numbers, on the basis of the largest average considered as 100; but the actual value of the largest average is given in the table, in parentheses. It may be supposed that the values give an approximate idea of the vegetative growth that had been made by the plants at the time of flowering, although of course they do not show the number of stools. This method gives only a somewhat rough approximation of the size of the plants; a more accurate method for comparing vegetative growth in such cultures might show the average stem height and the total leaf area for each culture. The relative height values have been classified in Table 3 into three groups, characterized as high, medium, and low, following a method similar to that used by Shive. The highest nine values are designated as high, indicated in the table by the letter H following the value; since two other values were the same as the lowest of the nine, these also are designated as high. Similarly, the lowest nine values are designated by the letter L. Medium values are without special designation in the table. The highest relative value is shown in bold-faced type. The relative values obtained with each of the three control cultures, and also their average, are given at the bottom of the column.

This division of the yield values into three large groups allows ready comparison to be made between these values and the salt proportions tested, and eliminates complexity that may result from small variations, due to unknown or uncontrolled conditions, such as hereditary variability of the plants. Only general conclusions, based upon large differences in plant measurements, may be drawn from the rather limited series of data here available.

The air-dry weights of tops are shown in the sixth column of Table 3, where they are presented as relative average values derived from two plants, classified as high, medium, and low, as in the case of the height values. The actual yield, in grams, of the culture giving the highest yield of tops is shown below the relative value (100) for that culture; actual yields for any of the other cultures can of course readily be calculated from these data. In order to bring out relations between the top yields and the proportions of the fertilizer salts employed, these data have been plotted on the triangular diagram of fig. 2, which is similar in arrangement to fig. 1. In fig. 2 the culture numbers have been omitted, and the yields of tops have been placed near the intersections designating the several salt proportions. The area representing high yields is here distinguished by small crosses, the culture giving the very highest value being indicated by a large cross; areas of low top yields are designated by small circles, the lowest value (obtained with three cultures) being indicated by large circles; and areas of medium yields are without special designation.

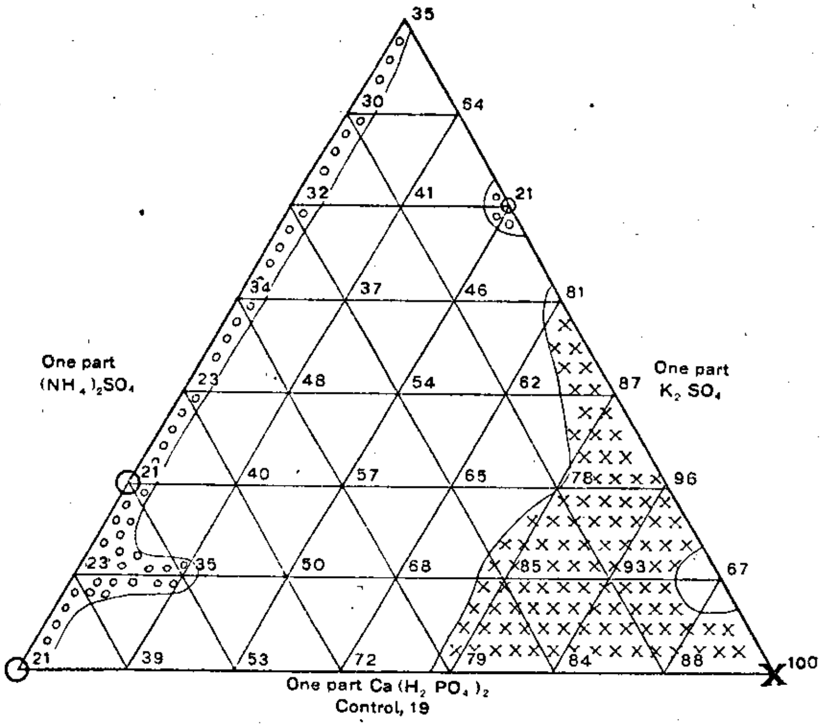

Fig. 2. Relative yields of rice tops. Area of low yields indicated by small circles; area of high yields, by small crosses. Highest yield indicated by a large cross; lowest, by large circles.

Relative yields of grain are shown in the seventh column of Table 3, where the arrangement and method of presentation correspond to those used for the other yield data; and the grain yields have been plotted on the triangular diagram of fig. 3, which is similar in arrangement to fig. 2.

The data showing the relative number of fruiting panicles in each culture are presented in the eighth column of Table 3.

DISCUSSION OF RESULTS

Relative dry yields of tops.—The triangular diagram showing the relative dry yields of tops (fig. 2) brings out some interesting relations between the proportions of the salts supplied to the soil and the resulting plant growth as indicated by the production of dry tops. In this diagram the area of high yields (denoted by small crosses) occupies the right-hand corner of the triangle, areas of medium yields occupy the central region, and the area of low yields (denoted by circles) embraces the whole of the left-hand margin of the triangle.

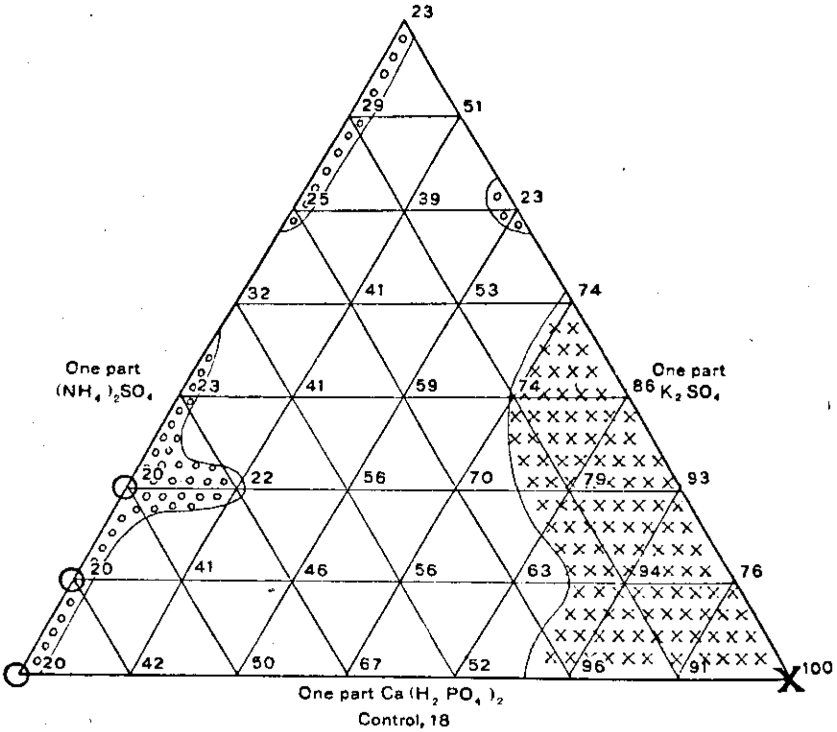

FIG. 3. Relative yields of rice grain. Area of low yields indicated by small circles; area of high yields, by small crosses. Highest yield indicated by a large cross; lowest, by large circles.

The area of high yields includes the cultures characterized by the highest proportions of ammonium sulphate, and it will be seen that no high yields were obtained when this salt made up less than 0.4 of the total osmotic value of the salt mixture. Culture R2C7 is apparently exceptional, since it gave only a medium yield, although it lies in a region where a high yield might be expected. With this exception, all the cultures having high proportions of ammonium sulphate gave high yields of tops. An examination of this diagram with reference to the proportions of the other two salts shows that high yields of tops were not obtained when potassium sulphate made up more than 0.4 of the total osmotic value of the mixture, but that many cultures having low proportions of this salt gave only medium or low yields. Furthermore, it is seen that high yields were not obtained when primary calcium phosphate comprised more than 0.5 of the total osmotic value, but that low or medium yields were obtained in many cultures in which this salt made up only a small proportion of the complete salt mixture. It is evident that high yields were definitely correlated with high proportions of ammonium sulphate (supplying the element nitrogen to the plants), and that high yields were not obtained with the highest proportions of potassium sulphate and primary calcium phosphate, but could not be related definitely to low proportions of these two salts.

It will be noted that the highest yield of tops was obtained with culture R1C8, having the following fertilizer mixture: 0.0154 gram molecule of primary calcium phosphate, 0.1228 gram molecule of amonium sulphate, and 0.0154 gram molecule of potassium sulphate. This salt mixture contains the highest proportion of ammonium sulphate tested, and the lowest proportions of primary calcium phosphate and potassium sulphate. The great increase in growth resulting from the addition of the fertilizer is shown by the fact that the yield of tops with the control culture, which was without fertilizer, was only 19 per cent of that obtained with culture R1C8.

Turning now to areas of low yields, it will be observed that these include a single row of cultures at the extreme left-hand margin of the triangle, together with two other cultures: R2C2, close to the left-hand margin; and R6C3, in the upper part of the right-hand margin. The latter culture, R6C3, is apparently abnormally low, occupying a region generally characterized by medium yields. Aside from this apparently exceptional culture, low yields are confined to cultures having very small amounts of ammonium sulphate; all of the cultures giving low top yields except R2C2 and R6C3, had only 0.1 of the total osmotic value of their salt mixtures due to ammonium sulphate. Inspection of the diagram with reference to the proportions of the other two salts—potassium sulphate and primary calcium phosphate—shows that low yields were obtained with all the proportions of these salts tested. There is thus no relation, in the present tests, between low yields of tops and the proportion of either the potassium or the phosphate salt.

The lowest yield obtained with any of the cultures, exclusive of the control, had a relative value of 21. This lowest yield, indicated on the diagram by large circles, was obtained with three cultures—R1C1, R3C1, and R6C3. The first two of these cultures giving lowest yields were characterized by the lowest proportion of ammonium sulphate and relatively low proportions of primary calcium phosphate. The third culture, R6C3, had a much higher proportion of primary calcium phosphate (0.6 of the osmotic value of its salt mixture) and a somewhat higher proportion of ammonium sulphate (0.3 of the total value of its salt mixture). The slight improvement in growth resulting from the addition to the soil of these poorest salt proportions is shown by the fact that the average yield of tops from the control cultures (lacking fertilizer altogether) had a relative value of 19, as compared with the lowest value of 21 from the cultures supplied with the poorest fertilizer mixtures. This difference is probably not significant, and the most poorly fertilized cultures may be considered as about equal to the controls.

Relative dry yields of grain.—The relative yields of grain are shown on the triangular diagram of fig. 3. Since it is the grain that is the commercial product of rice, the grain yield may be considered the most valuable growth criterion for this plant. As in the preceding diagram (fig. 2), the area of high yields is denoted by small crosses, areas of low yields by small circles, and the highest and the lowest yields are indicated by a large cross and by large circles, respectively. In its general characteristics this diagram for grain yields is very similar to the one for top yields. The regions of high, medium, and low yields on the diagram, fig. 3, correspond rather closely with those of fig. 2, thus showing that the several sets of salt proportions affected grain and top yields in a very similar manner. The area of high grain yields is confined to the right-hand corner of the diagram, corresponding to the highest proportions of ammonium sulphate. High yields of grain were definitely correlated, in these tests, with salt mixtures that contained high proportions of ammonium sulphate, and were never obtained when this salt made up less than 0.4 of the total osmotic value of the salt mixtures employed. As in the case of top yields, there was no clear relation, however, between grain yields and the proportions of either of the other two salts. Although high grain yields were not obtained when potassium sulphate made up more than 0.3 of the total salt value, nor when primary calcium phosphate comprised more than 0.5 of the total osmotic value of the salts supplied, nevertheless, high yields do not appear to have been determined by the proportion of either one of these two salts.

The highest grain yield was obtained with culture R1C8, and the same culture gave highest top yields. This culture, it will be remembered, is characterized by having the highest proportion of ammonium sulphate tested in the series, and by having the lowest proportions of potassium sulphate and primary calcium phosphate tested. The remarkable improvement in grain yield resulting from proper application of fertilizer salts is shown by the fact that the control cultures, which received no addition of mineral nutrients, gave a yield of grain only 18 per cent as high as that obtained with this best fertilized culture, R1C8.

Low grain yields were secured with practically the same sets of salt proportions as those that gave low top yields. As seen in fig. 3, low yields of grain were produced in the cultures denoted by the left-hand margin of the triangular diagram. Culture R6C3, as in the case of top yields, is apparently exceptional, since it gave low grain yields, although it occupies a position of the triangle where medium yields are indicated. It is apparent that low grain yields are correlated with low proportions of ammonium sulphate, which supplies the element nitrogen. With the exception of culture R5C1, low grain yields were obtained with all cultures in which ammonium sulphate formed only 0.1 of the osmotic value of the salt mixture. Culture R3C2, having 0.2 due to ammonium sulphate, and culture R6C3, having 0.3 due to this salt, also gave low grain yields. The proportions of the other two salts, potassium sulphate and primary calcium phosphate, do not appear to be related to the low yield of grain, since low yields were obtained with salt mixtures throughout the entire range of proportions of these two salts.

Lowest yields of grain were obtained with three cultures—R1C1, R2C1, and R3C1. As already mentioned, the first and third of these cultures also produced lowest top yields. The salt mixtures added to all three of these cultures contained the lowest proportion of ammonium sulphate tested, and low proportions of primary calcium phosphate, but contained high proportions of potassium sulphate. A very slight, but probably not significant, improvement resulted from the addition of these

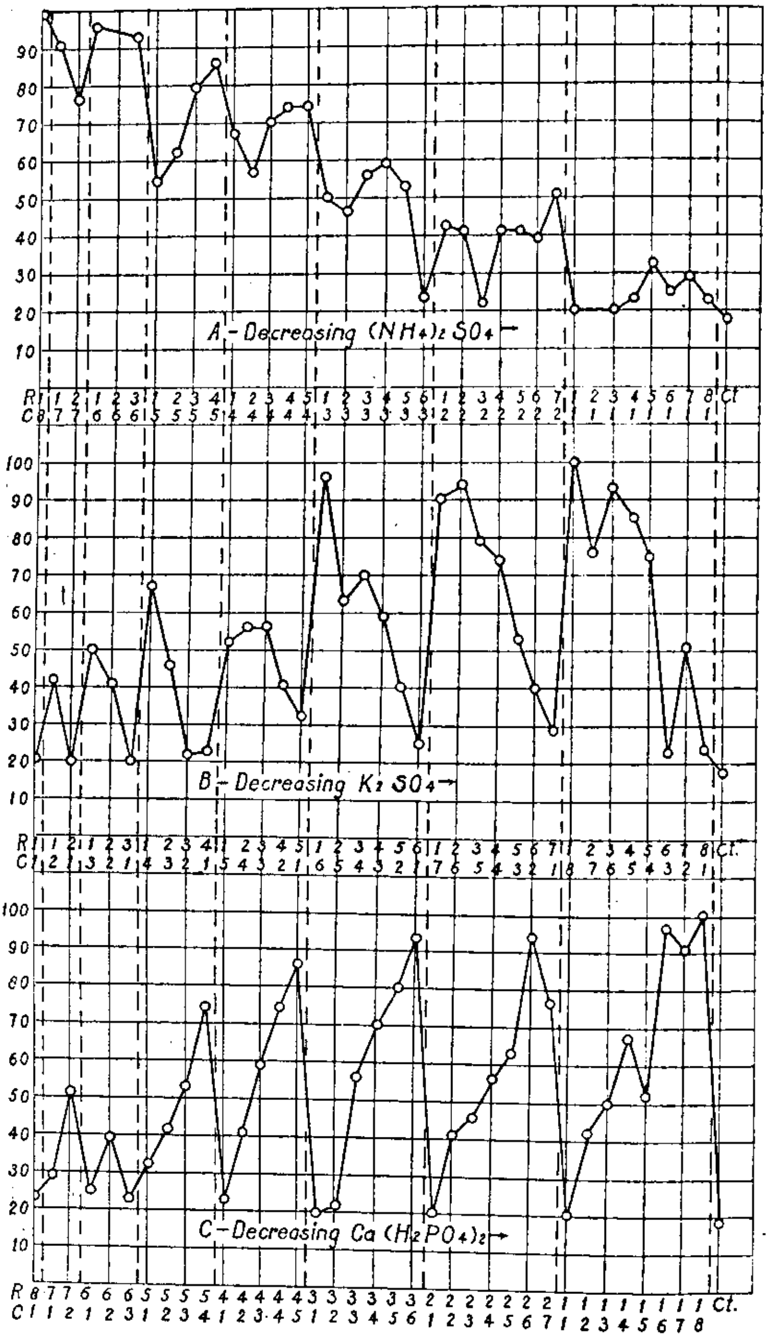

FIG. 4. Relative yields of rice grain as related to proportions of individual fertilizer salts. (Data are from Table 3.)

poorest salt mixtures to the soil, since the grain yield (20) obtained with these mixtures was slightly higher than the average yield (18) from the control cultures.

Grain yields and individual salts.—In fig. 4 the data of the relative yields of grain, given in the seventh column of Table 3 and plotted on the triangular diagram of fig. 3, have been replotted in such a way as to bring out relations that may hold between yield values and the proportions of the individual salts. In all three graphs of fig. 4 the relative yields of grain are plotted as ordinates. In the uppermost graph, A, the abscissas represent the cultures arranged as a series in the order of the magnitude of the ammonium sulphate content of their fertilizer mixtures, beginning with the culture receiving the highest amount of this salt and ending with the control culture having no fertilizer at all. In the middle graph, B, the abscissas represent the cultures arranged in the order of the magnitude of the potassium sulphate content of the fertilizer mixture, while in the lowest graph, C, the cultures are similarly arranged in the order of the magnitude of the primary calcium phosphate content of the salt mixture. The most striking general features of these graphs are that the uppermost, although showing minor fluctuations, indicates a strong general downward slope to the right, while the two lower graphs fluctuate widely, with some indication of a general upward slope toward the right. Each of the three graphs will now be considered in greater detail.

The uppermost graph was plotted in order to bring out any general relation that might exist between the proportion of ammonium sulphate (supplying the important element nitrogen) and the yield of grain. As just mentioned, the abscissas, from left to right, give the cultures arranged in order of the magnitude of the ammonium sulphate content of their fertilizer mixtures, and the ordinates represent the corresponding relative grain yields. The vertical dotted lines in this figure divide the cultures into nine groups; all of the cultures of each group received the same amount of ammonium sulphate, but they differed with respect to the proportions of the other two salts in the fertilizer mixture. A single culture (to the left of the first vertical dotted line) had 0.8 of its total salt addition due to ammonium sulphate; the second group of two cultures had 0.7 due to this salt, etc.; and the group of eight cultures, at the extreme right, had 0.1 due to this salt. Finally, the control culture, having no fertilizer at all, is plotted for the sake of comparison. This graph shows a strong tendency to fall rather uniformly in passing from left to right.

A generalized graph representing the downward slope of this graph might be shown by a straight line drawn from the value of 100, for the culture having 0.8 of its fertilizer addition due to ammonium sulphate, to a value of about 24, for the group of cultures at the right having 0.1 due to ammonium sulphate. It will be noted that the control culture, having no fertilizer, has a still lower value (18). Thus, with decreasing proportions of ammonium sulphate in the fertilizer mixture there was a general tendency for the yield of grain to decrease, which strongly suggests that the yield of grain, under the conditions of this experiment, was approximately proportional to the ammonium (nitrogen) content of the fertilizer mixture applied to the soil. This graph exhibits irregularities or fluctuations, which are in part due, no doubt, to unknown or uncontrolled conditions (such as initial internal differences in the plants used), and also in part due to the fact that the suggested proportionality between yield and ammonium sulphate content of the mixture does not hold rigidly—the proportions of the other salts also influencing the yield. It must be added that still higher yields may be expected when tests are made with salt mixtures containing still greater amounts of ammonium sulphate than any used in the present series. The results of a test with a salt mixture having approximately the proportions of culture R1C8 have indicated that increase in yield accompanies an increase in the concentration of total salt added, until the latter has an osmotic value slightly higher than 2 atmospheres. Thus, increase in yield may be expected to follow an increase in the ammonium (nitrogen) content of the salt mixture up to more than four times the amount used in the present tests.

The general proportionality between yields and the ammonium (nitrogen) content of the fertilizer is of course not surprising, since it has long been known that the amount of plant growth may usually be greatly increased by means of proper nitrogenous fertilizers. Russell,(12) page 32, in discussing the effects of nitrogen on cereal crops, states that the increasing effects produced, up to a certain point, by successive increments of suitable nitrogenous compounds may be due to the circumstance that the additional nitrogen not only increases the concentration of nitrogenous compounds in the soil, but also increases the amount of root (the absorbing surface) and of leaf (the photosynthesizing surface). The process thus resembles autocatalysis, where one of the products of the reaction acts as a catalyzer and hastens the reaction; but the increase does not go on indefinitely, because some other condition checks it. He further states that the first addition of nitrate causes a marked rise in the weight of the grain and the proportion of grain to the total product, but that successive additions show no further rise, and that an excess of nitrogenous fertilizer causes the proportion of grain to decrease, cereal crops producing a very high proportion of straw if the nitrogen supply is excessive. As will become evident from a discussion of the comparative plant measurements, in the next following section of this paper, that feature was not observed with the concentrations of ammonium sulphate employed in the study upon rice here reported.

The middle graph, B, of fig. 4 should indicate whether or not a correlation exists between the proportion of potassium sulphate and the yield of grain. The arrangement of this graph is similar to that of graph A, except that the cultures in the middle graph are arranged as abscissas in the order of the magnitude of their potassium sulphate content. This graph is irregular and fluctuates most widely in its latter half, where the yield values with each amount of potassium sulphate vary from the highest to approximately the lowest value of grain yield. The character of this graph indicates that, with the soil, the plants, and the general conditions of the present experiment, there was little or no general relation between the potassium sulphate content of the fertilizer mixture and the yield of grain. The only suggestion of a general trend in this graph is an upward slope in passing from left to right. This might suggest an inverse relationship between the potassium sulphate content of the fertilizer and the yield. But, if the conclusion reached regarding the rough proportionality between yield and ammonium (nitrogen) supply be true, then this indicated upward slope, in passing from left to right, may be explained by the distribution of the salt proportions tested. It will be observed that, with 0.8 of the salt mixture due to potassium sulphate, only 0.1 was due to ammonium sulphate; while with lower proportions of potassium sulphate much higher proportions of the ammonium (nitrogen) salt were used. Thus, the average content of the ammonium salt increases in passing to the right from one group of cultures to the next. If the yield is roughly proportional to the ammonium (nitrogen) content of the mixture and practically uninfluenced by the potassium content, then this moderately increased average yield with cultures having lower proportions of potassium sulphate is to be expected.

From the evidence of fig. 3, and of graph B of fig. 4, it thus appears that the increased proportions of potassium added to the soil in the present tests were practically without influence upon the yield of grain, or possibly even reduced the yield. This experiment, therefore, indicates that a marked increase in yield of rice grain is not to be expected when a potassium fertilizer, or a fertilizer containing very high proportions of a potassium salt, is added to the soil, under conditions similar to those of the present experiment.

An examination of graph C of fig. 4 furnishes conclusions regarding primary calcium phosphate that are similar to those given regarding potassium sulphate. This graph fluctuates very widely and exhibits a general tendency to rise somewhat with decreasing amounts of primary calcium phosphate. In a given group of cultures having the same content of primary calcium phosphate the yields vary from low to high values. This is apparently explained by the fact that the corresponding proportions of ammonium sulphate also increase in the same manner. The tendency of the average value of each group to increase somewhat as the proportion of phosphate decreases is interpreted to be due principally to the fact that the average proportion of ammonium (nitrogen) increases in a similar way. Primary calcium phosphate appeared in the present tests to be practically without influence upon the yield of grain, or to exert a slight retarding action upon this yield. Consequently, the evidence presented by the graphs of fig. 4 indicates that slight benefit is to be expected from phosphate fertilizers, under the present experimental conditions, when compared with the very great benefit resulting from the ammonium (nitrogen) fertilizer.

Logical thoroughness in the interpretation of these results requires that at least mention be made of a point that cannot be discussed adequately at the present time. The chemical elements—nitrogen, phosphorus, potassium, sulphur, etc.—may or may not be the units that are important to the plant. It is more probable that the ions—NH_4^+, P^+, K^+, SO_4^-, etc.—are the units that should be considered. The present tests make it logical to conclude that ammonium sulphate [$(NH_4)_2SO_4$] made the plants grow better, and that the other salts had little or no influence beyond determining the partial concentration of the ammonium sulphate. If, however, it is stated that the nitrogen (N) content of the fertilizer mixture is apparently effective in determining certain differences in growth, the conclusions are carried somewhat further than the experimental results justify. It must first be shown that the sulphate ion ($SO_4^=$) did not account for the improved growth. Indirect evidence that the sulphate ion did not determine the growth is furnished by the fact that increased yields were not obtained with increased proportions of potassium sulphate. Following this rather indirect line of reasoning, it is apparently safe to conclude that the ammonium ion (NH_4^+) in the fertilizer mixture was responsible for the increased growth. Since the element hydrogen of the ammonium radicle could hardly be supposed to bring about marked improvement in plant growth, it might then be concluded that the element nitrogen (N) was the important material in the fertilizer mixture. But the element nitrogen is not always beneficial in promoting plant growth. Indeed, several studies have shown that nitrogen in the nitrate (NO_3^-) form is of but little use for rice plants.[3] Thus, the importance of the element nitrogen should not be given especial emphasis without, at least, qualifying statements regarding the chemical combination in which the nitrogen exists; and, in general, it seems advisable to avoid the older assumption that the element nitrogen is important to plants. To illustrate this point an extreme example may be cited: Potassium cyanide (HCN) would never be regarded as efficacious in promoting plant growth. In view of these considerations, it seems best to state the main result of this study in specific terms, as follows: Ammonium sulphate, in the present experiments, brought about a marked improvement in the growth of rice plants in soil cultures, while primary calcium phosphate and potassium sulphate had little or no influence upon the plants.

Comparison of plant data.—It seemed of interest to summarize the different kinds of quantitative plant data in a way that would allow a ready comparison between the relative values obtained with each culture. This has been done by means of the graphs of fig. 5, which is somewhat similar in arrangement to fig. 4. For each of the graphs the ordinates represent relative growth data, while the abscissas give the cultures arranged in the order of the magnitude of their grain yields, from highest to lowest. The uppermost graph, representing the relative yields of grain, has a rather uniform downward slope, from left to right, from 100, the highest value, to 18, the lowest. The

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[3] See Kellner, (6) Kelley, (5) and Espino. (3)

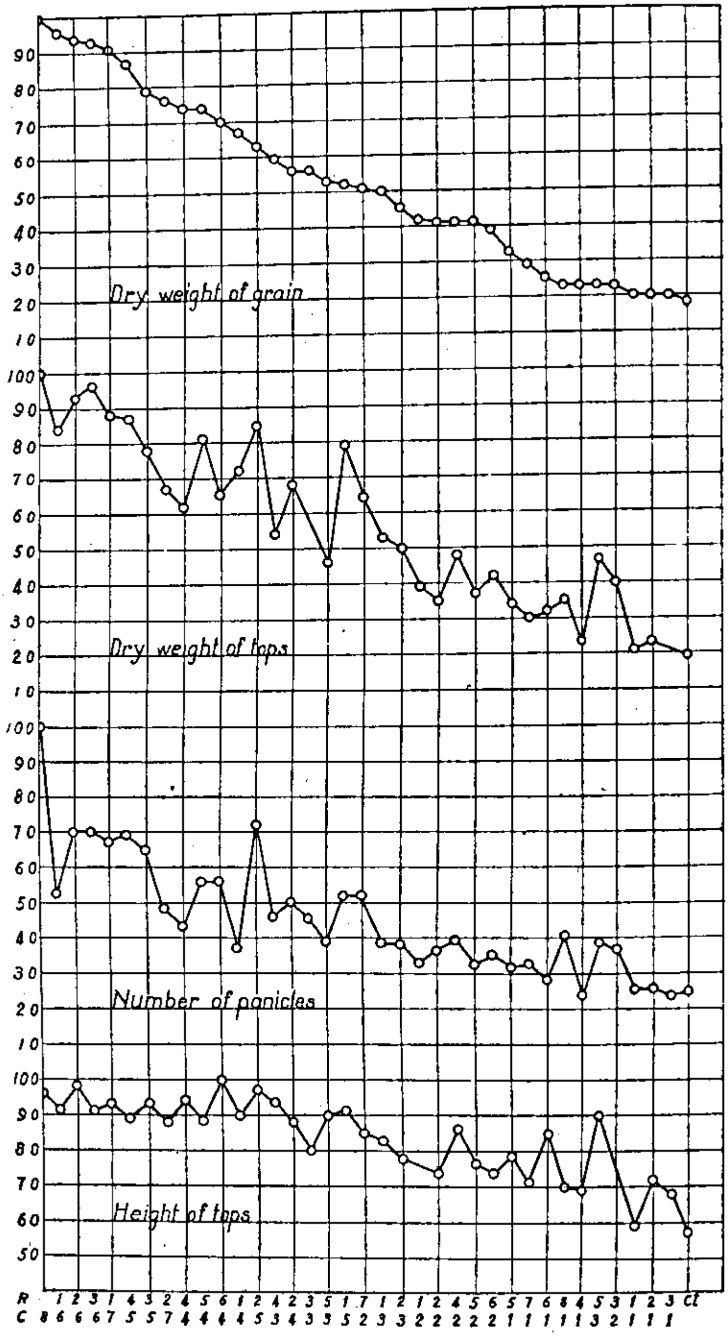

FIG. 5. Comparison between different kinds of plant measurements. (Data are from Table 3.)

lower graphs in this figure show the corresponding data of relative weight of tops, relative number of panicles, and relative height of tops, respectively, plotted with the same abscissas. The general slope and degree of fluctuation of the lower graphs give an idea of the degree of correspondence of the other kinds of data with those of the grain yield. By comparing the two upper graphs, it will be observed that in a general way they correspond in slope. The uppermost graph, showing grain yields, falls in approximately a linear manner from the value of 100 to 18, since the order of arrangement is that of grain yield. The graph below this, for top yields, is somewhat irregular, but has the same general downward slope as the graph for grain yields; in fact, the uppermost graph represents very well the smoothed graph that would be drawn from the graph of top yields. It may be concluded, therefore, that in a general way yields of grain and of tops were proportional to one another; both were affected in a similar way, and to about the same degree, by the same alteration in the various additions of fertilizer salts.

When the next graph, showing the relative number of panicles, is compared with the graph for grain yield, a smaller degree of correspondence is seen; still, the two graphs correspond in general form at least. Though the variations are numerous and in some cases great, the number of panicles is in a very general way proportional to the yield of grain.

The graph at the bottom of the page, representing the height of tops, fluctuates considerably, but differs from the graph for grain yield mainly in the fact that its slope is much less steep. The graph for height of tops shows a general downward slope from left to right; but the total range in relative values lies between 100 and 57, whereas in the case of the other graphs here considered the range is from 100 to approximately 20. Evidently, the various salt mixtures had a much less-pronounced influence upon the height of the plants than upon the number of panicles, the weight of the tops, or the yield of grain. This suggests that increased size in rice plants might be more definitely shown by an increase in the number and size of the stools than by an increase in the stem or leaf height.

General considerations.—The plant and the soil in which it grows form an exceedingly complex physico-chemical system, in which the processes are determined by many variable conditions. The development of scientific agriculture requires careful investigation of the general principles determining the rates of the processes that take place in this system, and proper fertilizer practice must depend upon a knowledge of these principles. Although investigators have been working for a century on the general problem of the salt nutrition of plants, nevertheless, scarcely more than pioneer work has thus far been done in this field. For the proper interpretation of the mineral requirements of even a single plant species, an enormous amount of research would be required. The present study suggests a number of problems that need to be subjected to careful investigation, some of which are mentioned below.

In the study reported in this paper only one total concentration of the fertilizer salts was tested. Similar experiments should be conducted with a range of total concentrations, from very low values to values that are well above the optimum.[4] In this way it will be possible to determine approximately the optimum proportions of the fertilizer salts at the optimum total concentration.[5] Such studies should enable us to determine the very best total concentration and the best proportions of these fertilizer salts for the growth of rice plants under the general conditions of these experiments. Studies should be made extending the sets of proportions to include single salts and mixtures of two of the salts used in the present study; since, under certain conditions, just as satisfactory growth may be obtained when only one or two of these salts are used as when all three are employed. Furthermore, such studies must be made to include many types of soils that are different from the one used in the present work. This is requisite because the amount and character of growth made by a given plant species is strongly influenced by the physical and chemical characteristics of the soil, and these characteristics influence the effect produced by fertilizer additions. Soil temperature, soil water content, and soil air content are likewise important. The studies must also include an investigation of the effects of different methods of cultivation, and must be extended to field tests. This phase of the problem will necessitate a study of the physical, chemical, and biological changes that take place in the soil as the result of the addition of fertilizer salts, and may involve a determination of the changes that the salts undergo after they are added to the soil. Such changes may be due to chemical reactions, to absorption phenomena, or to both.

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[4] It must of course be borne in mind that optimum conditions for one plant process are likely to be different from those that represent optimum conditions for other plant processes, and also that the optimum total concentration for one set of salt proportions may be different from that for another set.

[5] See McCall,(10) p. 214; also Breazeale,(1) Livingston,(7) Livingston and Hawkins,(8) Pulling and Livingston,(11) and Trelease.(16)

In the present tests, the total quantity of fertilizer was supplied in a single addition to the soil, made before the plants were placed in the latter. Obviously, an adequate investigation of this problem will require, also, investigations of the effects produced by adding the fertilizer salts at intervals during the growth of the plants.

Since the saprophytic organisms that inhabit the soil play a very important part in the chemical changes that take place in the soil, a further study must be made of the relation of soil bacteria and fungi to the plant reactions resulting from alterations in the supply of mineral salts.

The study here reported deals with the effects of additions of various proportions of salts containing elements that are essential to the growth of plants. Substances that supply only non-essential elements are known to produce marked alterations in the growth of some plants; and the reactions of plants to various stimulating or poisonous substances appear to vary with differences in the proportions and concentrations of the nutrient salts.[6] Therefore, studies of the kind here discussed must involve the elements that are likely to produce toxic or stimulating effects in the plant. Also, investigations should be made into the relation of soil aëration to changes induced by alterations in the mineral salts, with specific reference to the rice plant. Moreover, since the effects produced by altering the salt supply are very likely to depend upon the acid or alkaline reaction of the soil, this phase of the problem must be further investigated.

In the present work, three very common fertilizer salts have been employed; one supplying nitrogen in the ammonium form, another supplying potassium, and the third the phosphate radicle. These same nutrients may, obviously, be supplied to the plant in available forms by means of many other chemical substances besides those used in the present tests, and the plant responses may be expected to depend upon the nature of these substances.(9) Consequently, studies must be made of the effects produced upon the rice plant by supplying these necessary mineral nutrients through the agency of many other substances, including the so-called natural fertilizers, such as manures, soybean cake, etc.

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[6] See Brenchley,(2) and Free and Trelease.(4)

It is a well-established principle of plant physiology that the amount and character of growth made by a given plant species is greatly influenced by climatic conditions.(12) With other aërial conditions, the comparative results recorded in the present paper might have been very different. Consequently, adequate studies of the salt requirements of the rice plant must involve a consideration of climatic variations. Such studies will necessitate tests during the different seasons of the year, and will require a correlation of changes induced by alterations in the salt supply with fluctuations in the conditions of air temperature, sunshine intensity, and evaporating power of the air.

The preceding discussion has dealt exclusively with the conditions of the environment; first, the conditions that are effective around the roots and, second, those that are effective around the aërial parts of the plant. Besides these external conditions, it is well known that the internal conditions influence the amount and quality of plant growth; and, before general interpretations may be obtained regarding the salt nutrition of the rice plant, it will be necessary to employ many varieties of rice and to investigate the salt requirements during the various developmental stages of each of these varieties. The best salt proportions for vegetative growth of rice may be expected to be different from the best proportions for the period of flowering and fruiting.

It will be seen that the conditions in this system, composed of the plant and its environment, are exceedingly complex, and that the investigations here briefly outlined will require an enormous amount of work and time. The conditions surrounding the roots may be considerably simplified and more easily controlled by employing solution cultures or sand cultures instead of soil cultures; and it is probable that many of the lines of investigation here mentioned can be best approached by means of solution cultures and sand cultures, under carefully controlled laboratory conditions.

As yet we must depend largely upon the method of trial for determining what fertilizer salts and proportions must be used upon a given type of soil for a certain kind of plant growth. Thus far, general principles that may be applied to this problem have not been obtained; but a gradual advance in our knowledge of salt requirements may be expected to result from such trials.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Diagram showing culture numbers and osmotic proportions of the three salts.

2. Diagram showing relative yields of rice tops. Area of low yields indicated by small circles; area of high yields indicated by small crosses. Highest yield indicated by a large cross; lowest, by large circles.

3. Diagram showing relative yields of rice grain. Area of low yields indicated by small circles; area of high yields indicated by small crosses. Highest yield indicated by a large cross; lowest, by large circles.

4. Relative yields of rice grain as related to proportions of individual fertilizer salts. (Data are from Table 3.)

5. Comparison between different kinds of plant measurements. (Data are from Table 3.)

SUPPLEMENTARY NOTES ON THE SOCIAL BEES OF THE PHILIPPINE ISLANDS

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The discovery of a new species of *Bombus* on Negros Island is an event of considerable interest; and it is very satisfactory to obtain a new variety from Luzon, with the hitherto unknown male of *B. irisanensis.*

Bombus irisanensis Cockerell var. **baguionensis** var. nov.

The workers differ from the original description in having the fifth segment of abdomen in middle or right across, and the sixth, with long pale fulvous hair instead of black. The male has the hair of apical part of the abdomen black, as in the type. The clypeus of the male is covered with ocherous hair, and the third antennal joint is a trifle shorter than the fourth, the two together being scarcely longer than the fifth. The anterior wing of the male is about 16.5 millimeters long; the expanse, about 41. The first two abdominal segments in the workers have the hair pale fulvous or ochraceous; in the male it is darker, on the second segment almost a seal brown. In the male the hair of the legs is black, but in the workers the tibiæ have long fulvous hair, sometimes partly dark. It seems best, on account of the numerous differences, to distinguish this form as variety *baguionensis,* but it remains to be seen whether the Irisan type is racially distinct, or was described from a peculiarly colored individual. The type of the variety is a worker with fifth abdominal all pale haired, and the hind tibiæ and tarsi red. (*Baker 11841.*) The third antennal joint is distinctly longer than the fifth.

LUZON, Benguet, Baguio (*Baker 11840, 11841, 11842*), 1 male and 3 workers.

Bombus bakeri sp. nov.

Female.—Length, about 22 millimeters; anterior wing, 13.5; black, robust, very hairy; anterior and middle tibiæ and tarsi dark reddish, hind tibiæ and tarsi clear ferruginous; malar space about as broad as long; labrum bigibbous, fringed with red hair; third antennal joint a little longer than fifth, fifth longer than fourth; clypeus convex, smooth and shining in middle, punctured at sides; sides of clypeus depressed, separated from disk by a low ridge; clypeus overlapped by long fulvous to dark reddish hairs; hair of head otherwise, and of thorax entirely, rusty black, very dark; tegulæ black, obscure reddish posteriorly; wings pale reddish, orange-tinted, the broad outer margin more dusky; femora with black or dark hair, tibiæ and tarsi with light fulvous hair, ferruginous on inner side of tarsi; abdomen with rusty-black hair on first four segments, becoming red on apical part of fourth, and beyond this clear reddish fulvous.

NEGROS, Cuernos Mountains (*Baker 11839*), 2 specimens. In coloration this resembles *B. eximius* Smith var. *tonkinensis* Friese, but the malar space is much longer than in *eximius*. Structurally, the species is related to *B. irisanensis*.

Apis florea var. **rufiventris** Friese.

Apis florea var. *rufiventris* Friese, BUTTEL-REEPEN, Mitt. Zool. Mus. Berlin (1906) 170, 197; ENDERLEIN, Stett. Ent. Zeit. (1906) 338, 344.

PALAWAN. This has segments 1 to 6 of the abdomen almost uniformly red brown. The reddest form received from Sandakan, Borneo (*Baker*), has only the first two abdominal segments reddened, as described for typical *florea*. The form *andreniformis* (Smith), with black abdomen, also occurs at Sandakan.

Apis binghami Cockerell.

Apparently common at Manila, where Mr. R. C. McGregor collected a number of specimens November 7 and 9, 1918. They visit the flowers of *Antigonon leptopus* Hook. & Arn., according to a note supplied by Mr. McGregor.

Apis dorsata Fabricius.

SINGAPORE (*Baker 9220*). BORNEO, Sandakan (*Baker*). I have no specimens from the Philippines.

PROTOZOÖLOGIC AND CLINICAL STUDIES ON THE TREATMENT OF PROTOZOAL DYSENTERY WITH BENZYL BENZOATE

II. TREATMENT OF A CASE OF ACUTE BALANTIDIOSIS; RECOVERY; DEATH FROM OTHER CAUSES; FAILURE TO FIND THE PARASITES IN THE BOWEL LUMEN AND GUT WALL AT AUTOPSY [1]

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and
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WITH A PRELIMINARY NOTE ON THE ANATOMICAL FINDINGS AT AUTOPSY

By Walfrido de Leon
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In the first paper of this series the senior author, in collaboration with Doctors Lantin and Asuzano, (1) reported on the treatment of eight cases of acute entamœbiasis with benzyl benzoate. The results obtained in that series were so encouraging that it was determined to extend the experiments to affections produced by other intestinal protozoa. Subsequent experiments on cases of entamœbiasis have confirmed our earlier observations, but the treatment of flagellate infections has been, as was our expectation, much less encouraging. The case about to be reported is the first infection with *Balantidium coli* that has fallen under our control since the experiments were started; and, although we report a single case with some hesitation, still, the circumstances under which the case was studied were, in some respects, so favorable, and the results we obtained so good, that we feel justified in making the report in order that other investigators may take up the work as opportunity comes to them. Moreover, it must be recalled that the clinical treatment of balantidiosis has always been more or less unsatisfactory.

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[1] Contribution from the laboratory of protozoölogy and parasitology, Bureau of Science.

When we first undertook the study of the material obtained at the necropsy of our case, the findings seemed relatively simple. But, as we continue the study of our sections and toto mounts, interesting problems present themselves and emphasize the necessity of a more thorough study of the material. Therefore, we have decided to report the autopsy findings very briefly in this paper and reserve the details for a paper to be published later, by which time we shall have, in addition to the material from this case, more material from other sources for comparison.

The salient features presented by the case now under consideration are as follows:

The patient developed dysentery late in December of last year. The stools were dysenteric in character and contained swarms of *Balantidium coli.* Bacteriological cultures were negative for *Bacillus dysenteriæ.* Local treatment was given by proctoclysis; but on January 10, when the case was first referred to the senior author, the patient had lost greatly in strength and appeared to be approaching death. On January 13, when treatment with benzyl benzoate was started, the patient was practically in extremis. The bowels were in almost constant motion, and he was apparently in great pain and distress. It seemed unlikely that any treatment would be successful.

However, four days after the treatment was started, all other forms of treatment having in the meantime been discontinued, the pain and tenesmus had entirely disappeared and the patient was passing formed, feculent stools; his appetite had shown distinct improvement, and he was able to sleep quietly. The treatment was continued for twenty-four days, the balantidia showing a general tendency to disappear and finally appearing in the stool for the last time on January 29, nineteen days before the death of the patient from causes unrelated to the dysentery.

During the course of the benzyl benzoate treatment the patient showed a slow but constant improvement as regarded his general condition. The dysenteric symptoms never recurred, and his stools, though occasionally soft, were always feculent. About February 12, however, he became sick again with symptoms indicating trouble in the respiratory tract. He rapidly grew worse, and died on February 17. His stool was examined for the last time the previous day. It was hard and feculent and contained no balantidia. The patient had received no benzyl benzoate since February 6.

Autopsy was performed one hour after death, the body still being warm. Scrapings were taken from points along the intestinal tract and search made in them for *Balantidium.* None was found. The site of the dysenteric process was found in the region of the splenic flexure. The ulcerative process had healed. This area was cut out with some of the neighboring gut, divided between the two operators (W. de L. and F. G. H.), and immediately placed in fixing solution. Subsequently it was all cut into many small blocks and embedded in paraffine. Several sections were cut from each block and stained. Study of these gave ample evidence of the former presence of the parasites, but we utterly failed to find the parasites themselves. This is in such marked contradistinction to the findings in the intestines of persons who have died of balantidial dysentery, that we are inclined to suspect that our patient had lost his balantidial infection some time before death.

The patient was a male Spaniard, 54 years old, and was admitted to the psychiatric ward of San Lazaro Hospital, Manila, on January 18, 1917, by the attending physician, Dr. Samuel Tietze. Doctor Tietze informs us that the man showed no symptoms of balantidiosis prior to the onset of the acute attack on December 21, 1919. The patient, previous to his admission to San Lazaro Hospital, had been confined in the Hospicio San José in Cavite. No earlier history was forthcoming from that institution. He was fairly well nourished and fairly neat in his habits. Mentally, he was depressed, idle and seclusive, mumbling in speech, and his answers to questions were senseless and irrelevant. Nothing in his history or habits gave us any clue as to the manner in which he became parasitized with *Balantidium.* A diagnosis was made of terminal dementia of the senile, arteriosclerotic type.

The dysenteric symptoms developed abruptly on December 21, on which day he was found lying on his bed, too weak to move about. He was having frequent watery stools, that were greenish in color and apparently was suffering much pain. Throughout the course of the disease we frequently were compelled to draw conclusions regarding the presence or absence of pain and tenesmus from a study of the patient's countenance, for his answers, when he answered at all, were misleading. We likewise found it difficult to determine the exact number of stools passed by the patient during the twenty-four hours. He usually failed to call the nurse when his bowels moved, and we had reason to suspect, in many instances, that the results ultimately found by the nurse represented the product of two or more stools. This naturally makes our clinical report more or less incomplete.

The patient refused all food and grew steadily weaker. He was given appropriate stimulation, but showed no improvement. *Balantidium coli* was first found in his fæces by Doctor Torbillo, of the hospital laboratory, on December 23. The stool was negative for *Bacillus dysenteriæ*. In the absence of any treatment of proved efficacy, santonin was given in the hope of benefiting the patient. It apparently had no effect.

The condition of the patient grew steadily worse. From time to time he vomited his food and finally refused to take any. As a consequence of this he became very weak. He was given proctoclysis with normal salt solution, which was usually poorly retained. On January 10, as the patient refused to take anything by mouth, an attempt was made to administer nutritive enemata. As he was, at that time, having almost continuous bowel movements accompanied by much pain and tenesmus, this attempt, as might be expected, was not successful. Better results were secured later.

On January 10 the stool was examined for the first time by the senior author. It was totally devoid of fæcal matter and consisted mainly of balantidia, pieces of desquamated epithelium, and leucocytes, all suspended in mucus. Small numbers of erythrocytes were scattered through the mass, but the stool was scarcely "bloody." The balantidia, which were present in immense numbers, showed considerable variation in size, as if division were proceeding somewhere at an exceedingly rapid rate. A few dividing forms were seen in the stained preparations that were made at the time. All were in approximately the same stage of division—an early telophase—as if something had occurred to arrest the process.

There was little change in the condition of the patient for the next few days, aside from continued loss of strength. On the morning of January 13, however, the administration of benzyl benzoate was started in doses of ten drops of the 20 per cent alcoholic solution given in water three times a day. In the afternoon, the patient seemed to have experienced some relief, and he took food without resistance. The following day he was distinctly better and gave no sign of the presence of either pain or tenesmus. His bowels moved eight times. Five of these movements were reported by the nurse as being watery, one "resembled condensed milk," and two were soft and feculent. It is to be regretted that none of these was saved for examination.

The dose of benzyl benzoate was increased to fifteen drops, three times a day, on January 15. On January 17 the patient's bowels moved twice. The first stool, passed at 7 o'clock in the morning, was yellow, watery, and feculent. No blood or cellular débris was found. It contained numerous active balantidia. The second stool was passed at 9.30 a. m. It was yellow and semiformed and, like the earlier specimen, contained no tissue elements. A few sluggish balantidia were found; also numerous ova of hookworm and *Trichuris*. The latter continued to appear regularly up to the time of the patient's death. Both helminthal infections were very heavy.

The patient passed only one stool the following day, and it was not saved for examination. His general condition was much improved in every way. As he seemed to tolerate the drug well, the dose of benzyl benzoate was raised to twenty drops three times a day on January 19. His bowels moved once, but the specimen sent to the laboratory was unfit for examination, so no stress can be laid on our failure to find parasites on that day. A few vigorous balantidia were found the next day, however, and on January 21, notwithstanding the patient was eating and sleeping well, his stool, which was soft and yellow, contained traces of mucus and swarms of healthy-looking, vigorous balantidia. The parasites appeared to be as numerous as they were at the height of the acute stage of the infection and their increase in numbers was abrupt and very marked. On January 22, the stool was diarrhœal, but contained no albuminous matter. No balantidia were found in either the fresh or the stained preparations. A few badly plasmolyzed balantidia and some that were dead were found in the stool the next day, however; but with them were several hookworm eggs in a late stage of segmentation, indicating that the condition of the balantidia was due to the age of the stool rather than the action of the drug.

The general soft and feculent character of the yellow stools was maintained until February 1, when the fæces became hard and constipated and so remained until the patient died. The balantidia appeared in the fæces for the last time on January 29, when four sluggish, badly deformed individuals were counted in the examination of twelve fresh preparations, by the aid of the mechanical stage. The administration of the benzyl benzoate was continued, however, until February 6, when the patient vomited and complained of severe abdominal pain. We are inclined to believe it possible that the vomiting might have been caused by the drug, because, in one or two instances, the senior author has encountered patients who complained of a slight degree of nausea after the drug had been administered to them over a period of several weeks. However, the great majority of the patients studied by him have never complained of even this. In no instance has the nausea attributed to benzyl benzoate been in any way comparable to that produced in the general run of cases by ipecacuanha or emetine-bismuthous-iodide.

The abdominal pain subsided under paregoric, but the patient began to complain of general bodily pain, and on February 11 it was seen that he was very ill. He was unable to swallow his food. Later, he became delirious and suffered distressingly in his efforts to breathe. His stools remained well formed—a state bordering on constipation—and careful search failed to reveal any balantidia. The last stool was examined just twenty-four hours before the death of the patient, which occurred at 3.20 p. m., on February 17. It was negative for *Balantidium.*

The abdominal and thoracic cavities were open one hour and ten minutes later. The intestinal tract was removed as quickly as possible. Inspection of the body before this had led to the discovery of a shallow but rather extensive infected ulcer about 5 centimeters in diameter over the prominence of the large trochanter on the right side.

The left pleural cavity contained about 150 cubic centimeters of sero-purulent material. The base of the left lung was slightly adherent to the pleura by fibrino-purulent adhesions. The right pleura was free and slightly moist.

The left lung was greatly congested at the inferior lobe, the base of which was hæmorrhagic. In two places the lung was greenish in color, necrosed and suppurating. Much purulent material was expressed from these necrotic areas. Purulent material was also expressed from the cut ends of the bronchi. The upper lobe of the right lung was pale, slightly pigmented, and slightly emphysematous. This lung was congested at the base. Thin, easily removable adhesions were found between the base of the left lung and the adjacent pleura.

Pathological changes were noted also in the heart, spleen, liver, and kidneys, which, so far as we can determine, seemed to bear no relation to the balantidial infection.

The alimentary tract was examined with particular care. Fæcal material was taken from points along the lumen of the intestinal tract, promptly fixed, and later examined for balantidia. None was found. The small intestine showed a slight thinning of the mucosa, and a marked thinning of the entire wall. The large intestine showed some œdema and slight induration of the wall which, at the points of flexure, was thickened. This thickening was slight in extent and was most marked in the sigmoid colon near the cæcum in the region of the splenic flexure. At this point the intestinal wall was thicker, rougher, and more congested than the rest of the gut and showed petechial hæmorrhages. It was firm in consistence.

Here the mucosa was slightly congested and dirty looking. There was evidence of an increase of the mucous secretion and of epithelial desquamation. No ulceration of any kind was noted macroscopically in any portion of the gut. The anatomical diagnosis was: Toxæmia, acute vegetative septicæmia, aortic endocarditis, abscess of the base of the left lung with fibrino-purulent pleurisy, acute bronchopneumonia of the base of the right lung, fatty degeneration of the viscera, chronic catarrhal colitis, and hæmorrhagic infarction of the spleen.

The area of the large intestine that had been the site of the healed colitis was excised and divided between the two operators. That taken by the pathologist was fixed in Zenker's fluid; that taken by the senior author was fixed in Bouin's picro-aceto-formol fluid. Pieces were similarly cut from the ileum near the ileo-cæcal valve and from the duodenum, divided and fixed similary. Blocks cut from the other viscera were fixed in Zenker's fluid.

After thorough washing out of the fixing fluid, the intestine was cut into many small pieces. These were embedded and sectioned. We fully expected to find balantidia in the intestinal tissues, notwithstanding we had failed to find them in the lumen of the bowel, and when sections from the first few blocks failed to yield any, we were at first mildly interested; but when we had cut and stained three to five sections from each block of the Bouin-fixed tissue, and had utterly failed to find any parasites, our interest was thoroughly aroused. More sections were cut from the same blocks and also from blocks that contained apparently undamaged tissue, but the search for balantidia was still fruitless. We also failed to find balantidia in blocks of the tissue that was fixed in Zenker's fluid. Needless to say, we found no parasites in the lung, liver, or other viscera.

As stated in the beginning, it is not our intention at this time to describe in detail the pathological changes observed on study of our preparations. While we failed to find parasites in their customary habitat or, indeed, in other localities where we have found them in other cases, we certainly discovered in the intestine what we, at present, are inclined to interpret as unmistakable evidence of their former presence. But some of the points involved are too fine to warrant any positive statements on our part until we have gone over the material repeatedly and cut new sections and compared them with sections cut from other cases. Then we may be able to add something definite to what is already known concerning balantidiosis in man.

The general microscopic picture presented by our sections was cloudiness of the muscular coat and moderate injection of the blood vessels. There was some œdema of the submucous coat and of the interglandular tissues, with slight diffuse infiltration of the superficial mucosa with polymorphonuclear leucocytes and a moderate number of plasma-cells. The material showed a catarrhal colitis, with some very superficial ulcerations accompanied by slight secondary infection.

In any event, it cannot be said that our failure so far to discover balantidia in the tissues was due to their destruction by post-mortem changes, for our tissue was fixed, and well fixed, within one and a half hours following the death of the patient. Balantidia in a fair state of gross preservation have been found in tissues fixed twelve hours and more after the death of the patient. Our material, particularly that portion fixed in Bouin's fluid, was in excellent condition, and there was remarkably little shrinkage of the glandular elements.

Aside from the interest it holds to the student of the problems connected with protozoal dysentery, this case is of interest to the clinician, by reason of the fact that the treatment of balantidial dysentery in the past has been anything but satisfactory. The ipecacuanha compounds seem not to be as efficacious as they are in entamœbiasis, and other modes of treatment have been disappointing. If it is possible in subsequent cases to secure results similar to those we seem to have attained by the use of benzyl benzoate in this case, the outlook for the patient will appear more favorable.

Mason(4) has recently reported on the treatment of a case of balantidiosis, occurring in a Danish missionary in Yunnan Province, China, with oil of chenopodium and olive oil injected directly into the lower bowel. The acute symptoms cleared up very promptly. The patient had a slight relapse six days after the second treatment and was treated again. The case was under observation for three weeks, at the end of which time the stools were negative for the parasites and the patient seemed perfectly well. Mason takes a conservative view of his case and admits the possibility of a relapse, but reports his findings as we do ours, for what they may be worth to other investigators. We gather from his account of the case, however, that it was not nearly so severe as ours, for his patient seems to have been ambulant. Three weeks' observation is too small a limit to place in determining a cure, as Mason seems fully to realize.

SUMMARY AND DISCUSSION

By Frank G. Haughwout

A case of acute balantidiosis, complicated by infections with hookworm and *Trichuris*, was treated with benzyl benzoate.

At the time treatment was started, twenty-three days after the onset of the disease, the patient was exhausted and apparently near to death.

The abdominal pain and tenesmus, associated with the dysenteric process, disappeared within twenty-four hours after treatment was started and did not return again, even after treatment was stopped twenty-four days later.

The parasites showed a tendency to diminish in numbers in the fæces until the eighth day following the institution of treatment, when they suddenly appeared in the stool in immense numbers. On this day the stool was feculent, but contained mucus. No demonstrable tissue elements were found. I am inclined to regard this as the expression of a wholesale exodus of the ciliates from the tissues.

I believe that, had the patient not been under treatment, this "swarming" of the parasites would have been accompanied by pain, tenesmus, and the other symptoms constituting the dysenteric complex.

That the patient did not exhibit the symptoms that ordinarily accompany the departure of such large numbers of parasites from the tissues is, I believe, largely due to the selective action of benzyl benzoate. This drug, as Macht(2) has shown, acts in a manner similar to papaverin, in that it tends to inhibit peristalsis of smooth muscle organs, and lowers their tonicity and relaxes their spasm.

It is to be noted that Mason's patient suffered a relapse of a somewhat similar nature, six days after the second course of treatment was administered.

Observations I have made on this and other cases of balantidial infection, indicate the likelihood that *Balantidium coli* behaves in the tissues very much as we believe *Entamœba histolytica* [2] behaves. It seems likely that during clinically quiescent periods of the infection there is a more or less constant migration of the parasites, in relatively small numbers, back into the lumen of the intestine as a part of the normal life-cycle activities of the organism. The natural outcome to be expected as a result of this would seem to be the prompt encystment of the organism as soon as it reached the lumen, but apparently this does not usually occur in man. The ciliates thereupon find

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[2] It will be noted that in this article the dysentery amœba is referred to as *Entamœba histolytica*, whereas, in the first paper of the series it is spoken of variously as *Entameba dysenterica*, *Entamœba dysenterica* and *Endamœba dysenterica*. Likewise, *Ancylostoma* is styled *Ankylostoma* in the table. Furthermore, there are allusions to "endamebiasis," "endamebic dysentery," "endamebas," and "amebas." This has led at least one entirely competent and discriminating reviewer, Trop. Dis. Bull. 15 (1920) 190, to employ the accusing "(*sic*)" after some of these incongruities. With the reviewers, I have no quarrel; indeed, I am deeply grateful to them for unconsciously directing attention to what seems to me a growing and intolerable tendency on the part of the editors of certain medical journals to alter accepted zoölogical terms to accord with their own notions and terminology. Not only do they commit an offense against rules that have been adopted after much thought and deliberation on the part of entirely capable zoölogists and which surely are as helpful to the physician as the zoölogist in that they aid him in the interpretation of the reports of the zoölogist, but they clog the literature with vague and incorrect terms.

It is perhaps needless for me to say that as sent to the publisher, the terminology used in the manuscript was *Entamœba histolytica*, *Ancylostoma*, entamœbæ and amœbæ. The only alterations of consequence that were made in the copy in its preparation for the compositor were made in these zoölogical terms. The onus of the offense naturally falls upon the unoffending authors—particularly the senior author—and the offense is all the more heinous in that he has occupied the chair of protozoölogy in a large university in the tropics for several years. Had the paper been written by medical men who had never specialized in protozoölgoy, the offense could, in a measure, have been condoned as those things have been conthemselves unprotected in a most unfavorable environment for locomotion and the procuring of food suited to them. If the fæces are hard and lacking in moisture, the greater number of the organisms probably perish before reaching the anus. On the other hand, if the fæces are soft or fluid, the parasites live long enough to be seen by the microscopist, if he examines the stool with reasonable promptness. So far, there seems to me no good evidence that *Balantidium coli* derives any nourishment from the fæces—indeed, the indications are that nothing whatever is taken in through the cytostome after the balantidia leave the tissues. This, of course, lends support to the supposition that this species of *Balantidium* is an obligatory tissue parasite in man.

However, when something happens to bring about the expulsion, in large numbers, of the parasites from the submucous tissues, a tremendous stress is placed upon the tissues. The parasites appear to make their way down between the glands of Lieberkuhn and the supporting stroma. When they do this in small numbers, the separation of the tissue elements probably closes up rather promptly, and the relatively few bacteria en-

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doned in the past. The editorial indecision that led to the designation of the generic name by three separate spellings can only be regretted. All this necessitated the attachment of errata slips to each reprint of the article that was sent out.

I know of no amœba bearing the specific name "*dysenterica,*" and search of the literature has so far failed to reveal one to me. Therefore, I certainly do not care, in view of the present state of our knowledge of the parasitic amœbæ in man, to stand sponsor for any further additions to the already confusing synonomy of *Entamœba histolytica.* Doubtless the person who made this alteration in our manuscript had heard of the name *Endamœba dysenteriæ* as employed by Pestana after Councilman and Lafleur, and, with the object, perhaps, of making the name run more trippingly off the tongue of the busy practitioner, changed it to "*dysenterica.*" Manifestly, economy of space was gained by changing entamœbæ to "endamebas" and amœba to "ameba," although the latter term may be colloquially used as a group name with more or less propriety.

I am one of those who are in entire accord with Prof. Clifford Dobell regarding the inconsistency and inadvisability of substituting the specific name *dysenteriæ* for Schaudinn's ill-chosen, but nevertheless time-honored, name *histolytica* as the specific name for the dysentery amœba. In view of this it is, to say the least, somewhat disconcerting unwittingly to be made to appear as contradicting the teaching and writing of years. I cannot regard it as a mitigating circumstance that the proof of this paper was read in the United States by a friend who, though a scientific man, is not a zoölogist, and who could not be expected to cross swords with the editor on a question of nomenclature.

tering at the point of exit are probably promptly disposed of by the leucocytes.

On the other hand, when large numbers of the parasites are passing out, this reparative process is hindered and the intestine responds to the developing irritation by increased peristalsis that quickly becomes excessive. It is not improbable, then, that the violent peristalsis assists in the desquamation of epithelial structures already separated from their supporting tissues and, as a result, groups of epithelial cells become detached and contribute their share to the microscopic picture. The gates are then open to secondary bacterial invasion and the battle is on.

It would seem as if benzyl benzoate, through its specific action on the smooth musculature of the intestine, might inhibit this suicidal tendency on the part of the organism. This may be the reason why our patient did not show the clinical picture of acute balantidiosis with his parasitic relapse of January 21. It also may explain how it happens that a patient may pass frequent stools consisting mainly of tissue débris, pus, and parasites on one day, and four days later pass practically normal, feculent stools in which no traces of cell débris can be detected. Such were our observations in this case.

The case, however, raises other questions regarding the action of benzyl benzoate on intestinal protozoal infections. So far as our study of the material has progressed, the autopsy seems to have furnished evidence that a cure, in an absolute sense, was brought about coincidentally with the employment of the drug and possibly as a direct result of its action on the parasites. Balantidia were absent from the fæces for nineteen days prior to the death of the patient, although this, in itself, is not by any means convincing. But at autopsy we failed to find any in the lumen of the intestine. Furthermore, a thorough search of the tissues has, so far, failed to yield any of them; they may be there, but we have not found them yet. Has the drug a specific protozoöcidal action? That is to be suspected, but remains to be proved. The work of Macht and Fisher,(3) on the toxic effects of benzyl benzoate on the free-living ciliate *Paramœcium putrinum*, is no more convincing on that point than are many other similar, painstakingly conducted experiments with free-living protozoa or with parasitic species in vitro. However, their suggestion that such specific action on parasitic organisms may follow the splitting off of the benzol radical in the metabolism of the drug should be carried well in mind.

I have noted, in connection with several cases of intestinal entamœbiasis treated with benzyl benzoate, that the patients apparently did not pass cysts as convalescence progressed. This has seemed worthy of note in passing, but I have seen the same thing occasionally when other drugs have been employed; and it not infrequently happens that persons infected with *Entamœba histolytica* fail to discharge cysts, in sufficient numbers to admit of their detection in the fæces by the methods usually employed, for periods of weeks or even months. Unfortunately, we have been unable to keep track of our discharged amœbic cases, so we cannot tell if they are still infected. However, only one of these has applied to us for treatment of a relapse, and he had previously left the hospital notwithstanding his fæces still contained motile *Entamœba histolytica* and we had warned him that he was far from cured.

To settle the question as to whether or not this patient was absolutely sterilized as regards his *Balantidium* infection it would, theoretically at least, seem necessary to make serial sections of the entire colon. However, this is obviously impractical, even had we fixed and embedded the entire organ. It has only been possible to minimize the chances of missing the organisms by dividing the tissue into many small blocks and taking sections from each block. This we have done and, so far, we have been unsuccessful in our search for the organisms. We offer the evidence that we have collected with the promise to continue our studies and report in greater detail in the near future.

The clinical phenomena observed in this case were, in general, similar to those we have seen in our entamœbic cases. While we have had opportunity so far to treat only two cases[3] of balantidiosis, I am inclined to believe that we shall find benzyl benzoate to be as efficacious in balantidial as it seems to be in entamœbic infections.

It is again seen that the drug exerts no influence on helminthal infections.

The death of the patient was clearly due to causes unrelated to the balantidial infection.

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[3] As this paper is being written I am studying a case, somewhat similar to the foregoing, with Dr. Wenceslao Vitug, in the Philippine General Hospital.

ADDENDUM

As the final proof of this paper is being read, I am in receipt of a letter from Doctor Mason concerning the case of balantidiosis he treated with chenopodium in which he says:

> I saw my patient six months after treatment and he had had no return *then*. But I have since heard indirectly that he had a dysentery. This was a lay diagnosis. I sent him some chenopodium with instructions for its use. He wrote me later that he was well, but whether with or without treatment I do not know. I will write to him asking for a statement of his health since the first attack, and when I receive that I will send it to you.

REFERENCES

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2. MACHT, DAVID I. A pharmacological and therapeutic study of some benzyl esters. Journ. Pharm. & Exper. Therap. **11** (1918) 419.
3. MACHT, DAVID I., and FISHER, HOMER G. On the toxic action of opium alkaloids individually and in combination with each other on Paramecia. Journ. Pharm. & Exper. Therap. **10** (1917) 95.
4. MASON, C. W. A case of Balantidium coli dysentery. Journ. Parasitol. **5** (1919) 137.

REVIEWS

La Pratique | du | Pneumothorax | Therapeutique | par | F. Dumarest | Médecin en chef | & | C. Murard | Médecin adjoint | des sanatoriums d'Hauteville | Paris | Masson & Cie, Editeurs | Libraires de l'Académie de Médecine | 120, Boulevard Saint-Germain, VI | 1919. 261 pp., illustrated. Paper, 12 francs net.

The practice of artificial pneumothorax has been making considerable progress in recent years, and it is adapted to the varied exigencies of the clinic.

This book by Doctor Dumarest is a thorough study of artificial pneumothorax and gives complete information on the technic, apparatus, possible accidents, and also the medical rules by which the practitioner must be guided, in conducting treatment; in pleural complications; and in the study of remote results.

The work closes with physiological considerations of the mode of action of pneumothorax and touches upon the general indications and contra-indications encountered by this method of treatment.

Doctor Dumarest's practice, extending over many years, lends especial authority to his book. He has enriched it by various considerations, thereby making the use of this therapy possible to the beginner, especially when dealing with tuberculosis, which has wrought unprecedented ravages in France.

The main sections of the book cover: Apparatus, technic, accidents; conduction of treatment, constitution and evolution of pneumothorax, results, accidents, convalescence; pleural complications, frequency, clinical study, pathogeny and treatment of pleural complications; remote results, interruption of treatment; mode of action of pneumothorax; indications in pulmonary tuberculosis; counter indications, clinical technic.

Toxines | et | Antitoxines | par | M. Nicolle | E. Césari | C. Jouan | de l'Institut Pasteur | Masson et Cie, Editeurs | Libraires de l'Académie de Médecine | 120, Boulevard Saint-Germain, Paris | 1919. i–viii + 1–123 pp. Paper, 5 francs net.

This work is essentially a "personal" book; nevertheless, it may perhaps be considered a complete monograph and such an adjustment of the question of toxins as might be achieved by means of scientific experimentation.

Personal the work may seem at first glance because the authors are among those who have contributed most to an explicit understanding of the problems that arise from modern theories of immunity and the reactions of defense of the organism. Therefore, to study toxins and antitoxins from this point of view is largely to cite, and comment upon, their labors.

We repeat, it is a personal work, in the sense that no theory, however classic, is advanced by the authors, unless based upon laboratory verification, or unless the problem has been studied from the beginning, so as to eliminate incorrect interpretations. It presupposes many years of patient labor and the use of technical resources of a laboratory which it would be difficult to find elsewhere than in the Pasteur Institute. This book, which is a compilation of many studies, is confined to 123 pages. A mere glance will suffice to show the great care expended upon the arrangement of the divisions, the subjects treated, and the wide range of theories and facts it embodies.

Faithful to the classic method among masters of French science, and from which they rarely depart, the picture presented to us by M. Nicolle and his coworkers is devoid of all extraneous considerations; a large question is approached boldly and the authors go straight to the point without seeking support or theoretical assistance in affiliated considerations. This is what makes the monograph, though so brief, a systematic, complete, objective, and instructive exposition of the problem of toxins.

ERRATA

Pages 218 and 219, in the legends of Tables 2 and 3, for *Amphibia* read *Salientia.*

Page 228, line 2, *for* Total length 25 *read* Total length 250.

Page 228, before the center head RANIDÆ, insert:

Order SALIENTIA

Four limbs present; tail not present except in larval form; no intromittent organ; body short, more or less depressed. Two suborders are recognized, characterized as follows:

Key to the suborders of the Salientia.

a^1. Tongue present; separate inner ear openings.................... **Phaneroglossa.**
a^2. Tongue absent; a single opening to the Eustachian tubes........ **Aglossa.**

Suborder PHANEROGLOSSA

Only the suborder Phaneroglossa is represented in the Philippines. It is usually divided into two groups, each of which is represented by two families in the Philippines.

Key to the Philippine families of the Phaneroglossa.

a^1. Coracoids united by a simple epicoracoid cartilage; precoracoids resting with their distal extremity on the coracoid or connected with it by cartilage; precoracoid sometimes absent.......................... **Firmisternia.**
  b^1. Upper jaw toothed; diapophyses of the sacral vertebra not or only slightly dilated; precoracoids always present........................ **Ranidæ.**
  b^2. Upper jaw toothless; diapophyses of the sacral vertebra dilated; precoracoids present or absent....................................... **Engystomidæ.**
a^2. Coracoids and precoracoids connected by an arched epicoracoid cartilage, that of one side overlapping that of the other........................ **Arcifera.**
  c^1. Jaws toothless; diapophyses of sacral vertebra dilated.... **Bufonidæ.**
  c^2. Upper jaw toothed; diapophyses of sacral vertebra very strongly dilated .... **Pelobatidæ.**

Page 228, under RANIDÆ, line 1, *for* vertebræ *read* vertebra.

Page 232, line 8, *for* in habit, and are invariably found in water *read* in habit and are usually found in water.

Page 252, line 29, *for* of fifth toe smallest, prominent; inner etc. *read* of fifth toe smallest; prominent inner etc.

Page 269, line 8, *for* longer *read* larger.

Page 269, in table of measurements, last line, *for* 1.8 *read* 18.

Page 290, line 16, *for* Wiegman had a Manila specimen collected by Meyer for the *read* Wiegmann had a Manila specimen collected by Meyen for the.

Page 316, line 6, substitute a semicolon for the first comma.

Page 319, line 2, *for* vertebræ *read* vertebra.

Page 320, line 18, *for* vertebræ *read* vertebra.

Page 323, line 9, *for* slits on side *read* slits at side.

Page 328, line 29, *for* vertebræ *read* vertebra.

Page 332, line 2 of paragraph 2, *for* body *read* bony.

Page 333, line 6, *for* granular on *read* granular; no.

Page 334, last line under *Tadpoles*, *for* ticulation *read* tal characters.

Page 337, under BUFONIDÆ, line 1, *for* vertebræ *read* vertebra.

Page 337, in line 2 of the *Key*, *for* horinzontal *read* horizontal.

Page 339, in the table of measurements, *for* Tibia 65 *read* Tibia 6.5.

Page 345, last line, *for* Boie, from *read* Boie, a snake from.

Page 346, under PELOBATIDÆ, line 2, *for* vertebræ *read* vertebra.

INDEX

[New generic and specific names and new combinations are printed in clarendon; synonyms and names of species incidentally mentioned in the text are printed in *italic.*]

A

- Acacia farnesiana (Linn.) Willd., 533, 535.
  - farnesiana Willd., 377.
- Acalypha hispida Burm., 379.
  - wilkesiana Muell.-Arg., 379.
- *Acanthopneuste borealis* (Blasius), 368, 388, 394, 408.
- Accipiter confusus (Hartert), 405.
- Achras sapota Linn., 380.
- Acorus calamus Linn., 376.
- *Acridotheres cristatellus*, 365.
  - *tristis* (Linn.), 365.
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